By courtesy of *Aerofilms, Ltd.*

A General View from the Air

An " oblique " photograph showing a general type of English scenery *Frontispiece*

COMMERCIAL AIR TRANSPORT

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FOREWORD

I BELIEVE this to be the first real textbook on the absorbing problem of air transport to be placed at the disposal of the public. The idea of its production originated with the Council of the Institute of Transport, who have very wisely accepted knowledge and experience in air transport as a proper qualification for membership of the Institute; they have actually drawn up a syllabus for examination covering all aspects of this new activity. I, therefore, look upon this book as a milestone in the general progress of commercial aviation in the British Empire.

Air transport offers vast possibilities to us as a nation. On the one hand, quick communication has become one of the vital factors in the administration of the Empire; on the other hand, aviation has assumed a position of almost paramount importance in the problem of Imperial defence. The greatest defect in the organization of our Empire today is the fact that in this small island we have a considerably greater population than we can employ, whilst in other parts of the world, vast territories over which the British flag flies are crying out for population and development. Quicker communication must inevitably facilitate the settlement of a British population in our overseas dominions and colonies. One of the principal objections of the better class settler to leaving this country is the slowness of communication between our outlying territories and the homeland. If mails can be accelerated threefold by the use of air transport, as is possible in many parts of the Empire, the right class of man will be less reluctant to leave his native soil in Europe for endeavour elsewhere. Quick communications will also enable hardworked statesmen and business men to visit parts of the Empire which are absolutely out of their reach under present conditions of communication in the short periods of time which they

have available for travelling. Such visits must lead to better understanding, closer co-operation and increase of trade—all three of which are factors certain to bring benefits to our shipping and our home industries, and go far to strengthen the ties of Empire and ease many of our present difficulties of administration and intercommunication.

From the military point of view, a flourishing aircraft industry is absolutely essential for aerial defence; further, well established and properly organized air routes are necessary for the rapid transfer of air force from one portion of the Empire to another. Air transport will provide both these Imperial assets. The limiting factor in the volume of air transport to-day is the fact that it only exists through the artificial assistance of Government. The time is coming when this young industry will be able to operate without subvention; as soon as this desirable stage is reached, the demand for commercial aircraft throughout the world will be literally enormous. To every manufacturing country this new market will offer far greater commercial rewards than any military requirements during peace. It is inevitable that the nation which can obtain an appreciable proportion of the aircraft building trade of the world will automatically create a strong national reserve of pilots, mechanics, designers, and aircraft factories.

It is absolutely essential for our future well-being that we as a nation are paramount in the air. This end can only be attained through the unhesitating support of the public, and by the creation of an airfaring class which can compare with our unrivalled seamen of the past.

The first steps towards both these objectives must be devoted to education; education of the public to the enormous possibilities and vital importance of aviation to the Empire; and education of the youth of the country to enable them to embark on a career which will soon be without rival in Imperial importance.

The production of this book is a short but firm step towards this end. The Institute of Transport has offered a

definite diploma for knowledge in air transport; a diploma which should be accepted by the young industry in the same spirit as the older expert trades accept the diplomas of the older technical institutions. This volume contains a concise and clear exposition of air transport as it exists to-day, and provides most of the information required for the examination set up by the Institute of Transport.

Let us remember that the Empire was built up on our seafaring trade, and that even this old established method of communication has occasionally been supported in times of difficulty by means of subsidies and artificial assistance.

The Great War has left us a wonderful heritage in the air; every nation in the world is endeavouring to apply the new military weapon to the peaceful development of commerce and prosperity. Our widespread dominions offer a perfect field for the successful exploitation of air transport.

The great empires of history only existed so long as their communications were sufficiently rapid for sound administration. It is not too much to say that, if we fail to make full and efficient use of so vital a means of communication, our Empire may fade away into the mists of the past which have blotted out so many other imperial glories.

PREFACE

This small work is written in the hope that it may supply the student of the subject of air transport with food for thought by indicating the basic principles on which its operation is founded, and the lines which development and progress are likely to follow.

It is not intended to be a full and complete guide to a subject which is highly technical, the detailed treatment of which could not be compressed into a work of this size, but rather to be a general survey of the various problems which, when dovetailed together, complete the structural foundations on which air transport is being built.

Only such subjects of which first-hand experience has already been gained are dealt with from an operational point of view, hence merely passing reference is made to the operation of airships, which, nevertheless, it is confidently anticipated will play a very important rôle in the future development of air transport.

The authors desire to express their thanks to Lieut.-Colonel W. Lockwood Marsh, Mr. J. Hodgson, and Mr. B. Flowers for the assistance which they have given in the compilation of Chapters I and XIV; to the Air Ministry, Imperial Airways, Ltd., the Supermarine Aviation Works, Ltd., the De Havilland Aircraft Co., Ltd., the Gas Accumulator Co., Ltd., Sir W. G. Armstrong Whitworth Aircraft, Ltd., and Aerofilms, Ltd., for the permission which they have kindly given to make use of the photographs which appear in the book, and to Lep Transport and Depository, Ltd., for granting permission to make use of the table which appears in Chapter XV.

THE WHITE HOUSE,
SUNDRIDGE,
NR. SEVENOAKS.
27th May, 1926.

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COMMERCIAL AIR TRANSPORT

CHAPTER I

THE EARLY HISTORY OF FLIGHT

THE desire of man to fly is by no means confined to this modern age of science and invention, a fact which is clearly proved by very old manuscripts.

Legends and mythology of Ancient Greece and Rome, as well as those of Scandinavia and the East, contain many fables of winged flight. The beginning of aeronautical history in Great Britain commences with a legend of flight by Bladud, the mythological Tenth King of Britain, and the father of the equally mythical, but better known, King Lear. This king, who, as legend records, died in 852 B.C., made himself a pair of feather wings with which he apparently made an attempt to glide, but, his enthusiasm outstripping his skill, he presumably lost control, and the legend tells us that he fell upon the temple of his god Appolyon, in the city of Trinovantum, otherwise better known as London.

Later on, somewhere about 1020 A.D., Oliver of Malmesbury, is reported to have fitted wings to his hands and feet, and then, launching himself from a tower, maintained flight for more than a furlong, but the wind being too high he came fluttering down maiming all his limbs. Wilton relates of him that he " got so conceited of his art that he contributed the cause of his fall to the want of a tail, as birds have, which he forgot to make to his hinder parts."

An Italian adventurer, one John Damian, a favourite of King James IV of Scotland, attempted a similar kind of

performance from the top of Stirling Castle. This flight failed and the would-be aeronaut ascribed his fall to the fact that the wings contained hens' feathers mixed with eagles' feathers, which showed a natural affinity to return to the dungheap rather than to maintain flight in the air.

A satirical article on flight, contributed by Addison to the *Guardian*, in 1713, is the letter of Daedalus, in which the following passage occurs—

"I need not enumerate to you the benefits which will accrue to the public from this invention, or how the roads of England will be saved when we travel through these new highways, and how all family accounts will be lessened in the article of coaches and horses. . . . In short, Sir, when mankind are in possession of this art, they will be able to do more business in three score and ten years than they could do in a thousand by the methods now in use."

Many a true word is spoken in jest!

Leaving the purely legendary tales of flight, probably the first Englishman to write on the subject in any mechanical or scientific sense was Roger Bacon, A.D. 1250, to be followed 200 years later by Leonardo da Vinci, who designed extraordinarily interesting winged flying apparatus, helicopters and parachutes. He was followed by many other writers and scientists, but it was not until early in the twentieth century that any real advance was made in flight by heavier-than-air craft. Sir George Cayley, an amateur scientist and engineer, who was born in 1774, turned his mind to the problems of mechanical flight, and undoubtedly stands among the greatest pioneers of aviation; his early interest in aeronautics dates from 1796. During his lifetime he wrote what are still considered some of the finest essays on aerial navigation, his writings on airships, the basic principles of which he was the first to propound clearly, being quite as remarkable as his writings on mechanical flight. Indeed, as regards the former, it was his firm conviction that airships would ultimately prove the most efficient for trans-ocean and trans-continental

travel in conjunction with heavier-than-air machines over shorter distances.

He first experimented with gliders in 1808, with which he achieved a certain measure of success. The importance of Cayley's work lies in the fact that he not only carried out practical experiments, but combined the experiments with great theoretical considerations and scientific knowledge.

Prior to Cayley's time, of investigators of the problem of flight by heavier-than-air craft, of whom there were many, the majority had concentrated on attempting to produce the necessary lift and forward motion by means of flapping wings; all had depended upon human energy to produce the motive power. Cayley, however, became convinced that mechanical flight was the only possible solution of the problem, and he spent a considerable amount of time studying the question of engines—oil, steam, and electrical—which would be suitable for the purpose.

Cayley was followed by many scientists and writers, the most notable amongst them being William Henson and John Stringfellow, who, in association, added to the knowledge of the science of aviation, and especially the latter, who, about 1848, was the first man to produce an engine-driven aeroplane which actually flew. This was a large size model monoplane, fitted with a small steam engine which had been specially designed by him for the purpose.

In 1855, a French sea captain named La Bris, who had for some considerable time studied the flight of sea birds, commenced experimenting with gliders built to follow as closely as possible the lines of an albatross. After several years of patient endeavour he succeeded in evolving a machine with which he made some successful soaring flights.

Any brief account of the history of the development of flight would be incomplete without reference to the work of Otto Lilienthal, who built his first glider in 1891, and who before his death made more than 2,000 successful glides. Having, as he considered, sufficiently mastered the art of

flying he set about building an engine to work with compressed gas, and on the day on which he proposed to carry out his first flight with a machine equipped with this engine, he made a trial gliding flight with a new rudder control device which unhappily was responsible for his death. He did much to advance the cause of aviation.

About the same time Pilcher was experimenting in England. It was in 1895 that he built his first glider, after which he visited Lilienthal, in Berlin, where he flew one of the latter's gliders. Pilcher built several gliders with which he obtained considerable success. He regarded gliding, as some of his predecessors had done, as a means of obtaining proficiency in the art of flying, at the same time as he increased his knowledge of construction and of the forces to be contended with and overcome if he was to embark on flight with an engine-driven machine. He was faced with the same difficulty as his forerunners in that no engine was in existence which could be made really suitable for installation in an aeroplane. Having carried out work which entitles him to rank as a great pioneer of flight, he was killed in 1899 through the fracture of one of the stay wires in the tail of his machine.

Progress was being made during this period in the United States of America. In 1896 and 1897, Octave Chanute carried out numerous experiments in gliding with types of craft varying from biplanes to multiplanes. Experience showed him that he obtained better results with the former than with the latter. Professor J. J. Montgomery, who had built his first machine as early as 1883, carried out much successful work with automatically stable gliders, with the assistance of a band of paid acrobats, until in 1911 he was killed as the result of a crash. In the early eighties, Samuel Langley, then an old man, entered the field of aeronautics. He did much experimental work with small power driven models, and devoted much time to the development of a steam engine in which, to achieve lightness for a given output of power was the main problem to be

inhabitants over its surface. This necessitates the transfer of large numbers of people to far distant lands, and one of the great deterrents to adequate emigration is undoubtedly the feeling of wide separation which is conjured up in the imagination of possible breakers of new soil. Now if this feeling is analysed, it will be found that it is not due so much to the actual separation measured in miles as in time which is required to bridge these miles. Hence, if the time which is required to travel from one part of the globe to another is very appreciably reduced, one of the great deterrents to emigration will have been removed. Some idea of the extent to which air transport can effect this saving in time is shown in the illustration on page 14. On this account alone the establishment of air transport is amply justified.

Commercial aviation supplies an obvious reserve to service aviation by the provision of pilots, mechanics, technical personnel, aircraft, equipment, etc. Further, the creation of a full equipment of ground organization, especially on Imperial air routes, adds immensely to the value of service aircraft by increasing their mobility. The assistance which air transport can offer, and as it expands will continue to offer in increasing measure, to the defence of a country, provides perhaps the most obvious claim to subsidization.

Bearing on this last aspect there are two general principles of subsidy which may be applied. Firstly, either by the payment of a large subsidy in return for which a considerable number of machines, pilots and personnel must be maintained; or, secondly, by paying a comparatively small subsidy, while at the same time insisting on the practice of the utmost economy of operation. The first method obviously creates an immediate and tangible reserve for service aviation, but suffers from the severe defect that economical working is impossible when fleets and personnel are maintained out of all proportion to the needs of the services which are operated. Moreover it must be remembered that the operation of air transport services is still in

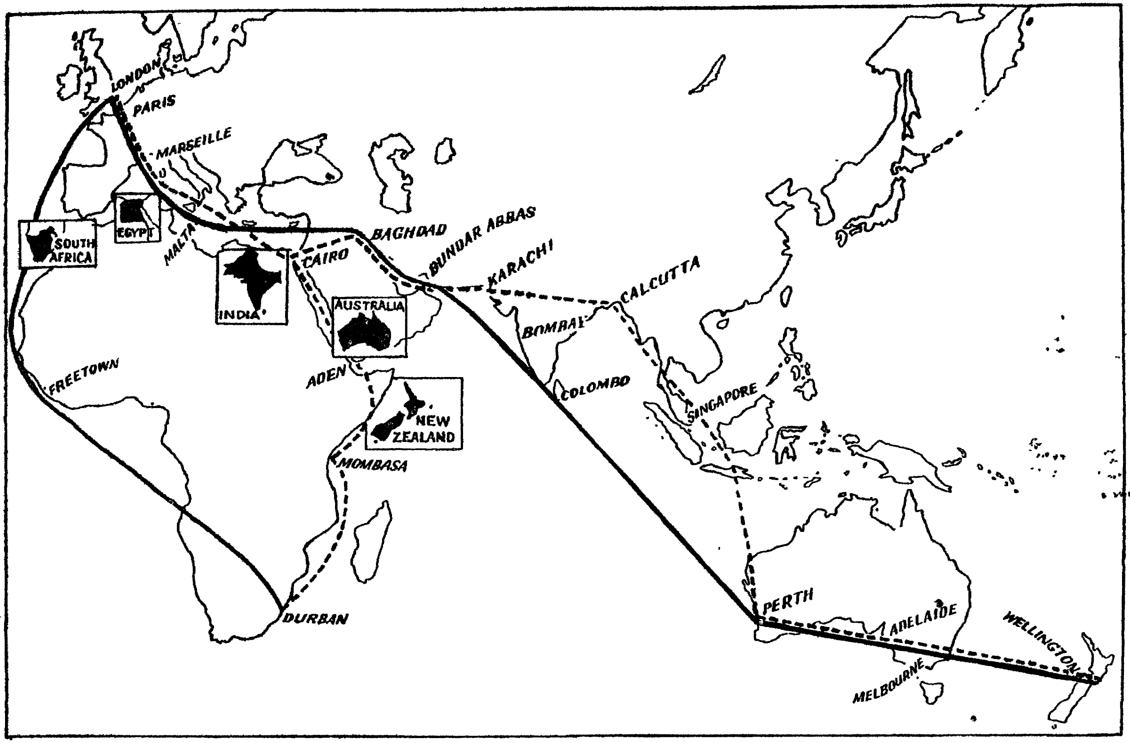


FIG. 2. IMPERIAL AIR ROUTES OF THE FUTURE

Illustrating the shortening of the time taken to reach various parts of the British Empire by the use of air transport; the dotted line shows an alternative route.

its infancy, and the ways and means of saving expenditure can only be learnt in the hard school of experience. Under the scheme of excessive fleets, the necessary lessons cannot be learnt and in consequence it follows automatically, that the time which will elapse before a paying basis of operation is reached must be considerably drawn out, during which period a large subsidy will be required to maintain a moderate reserve of material and personnel.

Under the second alternative of a small subsidy coupled with rigid economy of operation, the paying stage will be reached in the minimum period of time. During this period it is true that a negligible reserve will be provided. Once the paying stage is reached, however, there will follow an opening of new routes and an increase of services over existing ones, thereby creating a rapidly increasing demand for aircraft and the personnel with which to operate them, when a valuable reserve will be created automatically as the outcome of healthy trading conditions.

The British system of subsidy is based on this latter method.

There are obviously many ways by which subsidy may be allocated, whether the policy be one of large or small subsidies. A few examples will be sufficient to indicate some of the possible directions in which assistance may be rendered.

1. The State may purchase aircraft and either hire or loan them to the operating companies.

2. Aerodromes and general ground organization may be provided free of all charge. This may include repair facilities, for aircraft, engines, etc.

3. Fuel may be supplied without cost to an operating company.

4. Bulk mail may be handed over to a company for carriage at a fixed contract rate.

5. A percentage bonus on all traffic receipts may be paid.

6. Subsidy based on either the carrying capacity of the

fleet, the horse-power of the machines used, the mileage flown, or on a combination of these, may be paid.

7. The payment of a fixed rate of interest on capital may be guaranteed.

8. A bonus on efficiency and regularity may be given.

This list by no means exhausts all the possibilities. Moreover, when it is considered that any one of the methods enumerated above may be combined with either one or more of the others, it will be realized clearly that a problem which at first sight may appear to be a simple one is by no means so when it comes to applying it to actual practice.

Since the commencement of subsidized aviation, in 1919, the following systems have been in force in Great Britain—

1st period: Running costs plus 10 per cent on takings were paid for a number of flights determined by a minimum and a maximum on the London-Paris route.

2nd period: A payment was made of £3 per passenger and 3d. per lb. on goods. A further payment was made, based on 25 per cent of the traffic receipts. In addition a contribution of 50 per cent was made towards the insurance premiums paid on account of the aircraft used, while 50 per cent of the fleet was supplied by the Government on an advantageous hire-purchase system.

3rd period: The operating companies were given a free grant of certain aircraft and engines which had been purchased under the former scheme, the payments which had been made on account of hire purchase being refunded to them. In addition a fixed rate of subsidy calculated on a mileage basis on some routes, and on a flight basis on others, was given.

4th period: Payment was made purely on a mileage basis, the maximum mileage which had to be flown being specified.

5th and present period: Payment is made on a basis of horse-power mileage, it being necessary to fly a minimum number of horse-power miles, in order to qualify for the grant of the full subsidy. In this case the subsidy is

overcome. In 1893 he carried out his first trials with engine-driven working models with which, in 1896, he met with considerable success. By 1903 he had built an engine-driven machine which it was anticipated would be capable of carrying a man for a considerable period of time. Here a great stride forward had been made, as the engine which had been specially designed for this machine by Charles M. Manley was a five cylinder radial petrol engine, which is reported to have developed approximately 50 h.p. for a weight of only 125 lb. This machine was prepared for flight on 7th October, 1903, and it was only accidents, resulting from the fouling of portions of the machine with its launching gear on two occasions when taking off, that probably prevented Langley from occupying the proud position of being the first man to achieve flight in a power-driven aeroplane.

Let it not be imagined that the names of the pioneers mentioned above constitute a complete list of all those who, in spite of lack of support or encouragement, nay, oft in the face of open derision, persisted in their efforts to conquer the air. Such names as Wenham, De la Landelle, Brearey, Penaud, Moy, Hargreave Phillips, Sir Hiram Maxim, Adir, and a host of others all deserve mention for the parts which they have played.

The epoch-making event in the history of aviation was achieved by the Wright brothers on 17th December, 1903, when their flight was made on an engine-driven aeroplane carrying a pilot. This flight was the outcome of years of patient and intense study of the theory and the forces to be considered in the construction and flight of aircraft. Not only did the brothers open up a new era by their practical achievement, but they laid by a great store of knowledge of the science of aviation by means of the elaborate records kept by them of every detail of their experiments.

It must not, however, be imagined that the development of flight was dependent on the efforts of the Wright brothers, as simultaneously enthusiasts and experimenters in Europe

were independently striving towards the same goal and were not far behind the Wrights. Santos Dumont and a host of others amongst whom must be mentioned, Ferber, the Voisin brothers, the Farman brothers, and Bleriot in France, while in England, Phillips and Cody, who were followed later by A. V. Roe, Handley Page, Sopwith, De Havilland, Short and others, were making history. Although not designers or builders of aircraft, two of the earliest men to fly in England were Mr. (now Colonel) J. T. C. Moore-Brabazon, and the Hon. C. S. Rolls. The death of the latter, caused by a failure of part of the structure of his machine in the air, robbed aviation of one of its most prominent supporters.

The next milestone in the history of aviation was the flight of the Channel which was made by Bleriot in the early hours of Sunday morning, 25th July, 1909. The aeroplane in which he made his flight was a monoplane of his own design fitted with a three-cylinder Anzani engine of 25 h.p., the speed of the machine being thirty-six miles per hour. The flight started from Barraques and ended just behind Dover Castle.

A few days earlier Latham had made a gallant but unsuccessful attempt to span the English and French coasts by air, but he was frustrated by an engine failure when about eight miles from the French coast. He made a second attempt two days after Bleriot had won the *Daily Mail* £1,000 prize which had been offered for the first cross-Channel flight and was again unsuccessful, this time getting to within one and a half miles of Dover. Early the following year Jacques de Lessops made the second journey to be flown by aeroplane over the Channel, while in June, C. S. Rolls flew from Dover to Barraques where he was officially observed and returned to British soil without landing in France, thus carrying out the first return flight across the Channel and at the same time making the first flight from England to France.

The first aviation meeting to be held was at Rheims in

August, 1909. There were thirty entrants including one Englishman, Cockburn, and Glenn Curtiss from America. Records were made only to be broken almost at once. It may be regarded as noteworthy that no serious or fatal accidents occurred at this meeting, although Bleriot, owing to his machine catching fire, was severely burned.

The Rheims meeting was followed by many others which succeeded each other rapidly throughout the remainder of 1909 and the following year, many of which took place in England, the first being held at Doncaster in October, 1909

In 1906 the *Daily Mail* offered a prize of £10,000 to the first man who flew from London to Manchester within twenty-four hours. In 1910 Claude Grahame White and Paulhan each entered a Farman machine. Graham White started on his flight on 23rd April from a ground at Park Royal and made his first arranged stop near Hillmorten, a distance of seventy-five miles from his starting point, thereby creating a world record for a cross-country flight. He then continued his journey, landing near Lichfield. While waiting here a violent wind got up which eventually blew his machine over, doing a considerable amount of damage to it, and as it was then impossible to complete the journey within the limit of twenty-four hours, he had to send his machine back to London and make a fresh start. In the meantime Paulhan had arrived from France, and on 27th April started from Hendon. Grahame White, hearing of this, determined to try and beat him in spite of the fact that Paulhan had got a fifty mile start, and the first night of the race was spent with Paulhan still fifty miles in advance. Grahame White made a gallant effort to get level with his rival by starting an hour before dawn the following day, and had almost reached Paulhan, who was preparing to start, when engine failure forced him to land. Paulhan continued his flight and won the prize.

In 1911 another great race took place, being a 1,000 miles race round Great Britain for which a further prize had been offered by the *Daily Mail*. Nineteen entrants started, out

of whom four finished, Captain de Conneau of the French army, flying under the pseudonym of André Beaumont, winning the prize in a flying time of just under twenty-two and a half hours.

From this time onwards progress in both design and performance was rapid. The conquest of the air had now been accomplished, and flight was recognized as an art or science with real and practical possibilities, having finally emerged from the stage when anything which was connected with aviation was regarded as the product of a disordered imagination. To follow its development up to and through the years of the war is impossible in the space available. That the war was responsible in five years for a development which, under normal conditions of evolution, would have taken considerably longer, is obvious.

At the signing of the Armistice in 1918, the aeroplane had reached a high state of development from the point of view of military requirements, and it was from these machines that the commercial aeroplane, as we know it to-day, has been evolved.

The first regular services to be started were one from Hendon to Paris, and one from near Folkestone to Cologne, which were operated by Royal Air Force aircraft and personnel, the first for carrying officials to and from the Peace Conference, and the second for the carriage of official correspondence between London and the service headquarters which were established on the Rhine immediately after the Armistice.

On 26th August, 1919, the first commercial service commenced. This was a daily service in each direction between London and Paris, operated by Aircraft Transport & Travel, Ltd. This was followed in November by a similar service, operated by Handley Page, Ltd. During 1920 two additional companies commenced operations, S. Instone & Co., Ltd., and the Air Post of Banks, both operating between London and Paris, while the Handley Page Company opened two new services between London and Brussels,

By courtesy of *the De Havilland Aircraft Co., Ltd*

FIG. 1. THE FIRST CABIN AEROPLANE

A De Havilland 4A aircraft, fitted with a 375 h p. Rolls-Royce Eagle VIII engine, as used for the first London-Paris air service.

and London and Amsterdam, and Air Transport & Travel, Ltd., working in conjunction with a Dutch company, also opened a service between London and Amsterdam.

In 1921 only two services were being operated, one by Handley Page, Ltd., and the other by S. Instone & Co., Ltd., both between London and Paris.

During the first half of the following year, services were being operated by these same two companies and, in addition, Daimler Hire, Ltd., put on a service to Paris, whilst S. Instone & Co., Ltd., commenced operating to Brussels. Towards the end of the year, however, a shuffle round was made and extensions to the routes were added, Handley Page Transport, Ltd., now operating from London to Paris; Instone Air Line, Ltd., from London-Brussels-Cologne; and Daimler Hire, Ltd., from Manchester-London-Amsterdam. In 1923 further extensions were made, the London-Paris route being extended to Basle and Zurich, and the Manchester-Amsterdam service to Berlin, while a new service operated with flying boats by the British Marine Air Navigation Co., Ltd., was opened from Southampton-Guernsey. On the 1st April, 1924, these four companies were amalgamated into one company, Imperial Airways, Ltd., which up to date (January, 1926), has continued to operate the above services.

No record, however abridged it may be, of the development of commercial aviation would be complete without reference to some of the magnificent long distance flights which have been made.

In June, 1919, Capt. Alcock and Lieut. Whitten Brown flew across the Atlantic, starting from Newfoundland, and landing in Ireland. During November and December of the same year Capt. Ross Smith and his brother, Lieut. K. M. Smith, flew from England to Australia; whilst in February and March the following year, Wing-Commander Van Ryneveld and Flight-Lieut. Brand flew from London to the Cape.

The great achievement in long distance flying was made

by the U.S.A., when between 6th April, 1924, and 28th September, 1924, out of four pilots flying together, three, Smith, Wade, and Nelson, succeeded in circling the world. Some idea of the stage of development at which aircraft have arrived is evidenced by the fact that between November, 1924, and March, 1925, a journey was made from London to Burma and back by Air Vice-Marshal Sir Sefton Brancker, piloted by Mr. Cobham. The distance flown was approximately 18,000 miles, and to accomplish this the same machine and engine was used throughout. Later in the same year Mr. Cobham started on a flight from London to Cape Town, using the same machine but fitted with a higher powered engine. He left London on 16th November, 1925, leaving Cape Town on the return journey on 26th February, 1926. He landed at Croydon on 13th March, having flown the 8,500 miles from Cape Town to London in sixteen days. The fact that here again the same machine and engine was used throughout this flight of approximately 17,000 miles speaks volumes for the development in aircraft and engine construction which has taken place within the last few years.

These are but a few of the many wonderful flights which have been made, and as each of them has been brought to a successful conclusion, a new page in the making of history has been finished.

CHAPTER II

SUBSIDY

BEFORE dealing with the various methods by which a subsidy can be paid, let us consider for a moment the necessity and justification for the subvention of air transport.

In the first place, history has proved that once the requirements of a nation outstrip its resources in transport, decay sets in.

Apart from considerations such as those with which the British Empire is faced owing to its widely separated component parts, if one great power adopts a new and rapid form of transport, it behoves its rivals in commerce to adopt similar methods if they are to maintain their position.

Air transport was born as the result of the Great War, when it at once became obvious that aircraft had given the world a means of rapid and practical transport such as had only been dreamt of a few years previously.

An enormous proportion of the productive wealth of the world is always lying idle owing to the time which is wasted while money or its equivalent is being transported from one place to another. If this delay can be reduced it will have the practical effect of increasing the world's supply of available capital, which in its turn will cause an increase in the world's total wealth. Without entering into a discussion on economics, it is obvious that when a form of transport achieves this highly desirable result, not only can it not be ignored, but it is essential that advantage shall be taken of it.

Again, with the population of the world increasing as it is to-day, the greatest increase naturally occurring in the most thickly populated areas, it is becoming daily more urgent to obtain a more even distribution of the world's

decreased periodically while the horse-power mileage remains constant.

In each of the above periods a maximum possible payment was specified, over and above which no further payment in any one year was to be made.

It is generally agreed that, in principle, the subvention of any form of industry is undesirable. On the other hand, when the enormous benefits to commercial and social development which will follow when air transport fully matures, are taken into consideration, ample justification for the artificial assistance needed to support it through its period of infancy is provided.

CHAPTER III

STATE VERSUS PRIVATE OPERATION

A CONSIDERABLE amount of discussion has taken place and is still engaging the attention of the authorities in various parts of the world, as to the desirability or the reverse of the State undertaking the operation of air transport services. One of the contributing factors which influence those in favour of State enterprise is that since in the present stage of development subsidies are essential, there appears little or no justification for paying these subsidies to private undertakings. Again, in certain countries, civil aviation is regarded as a potential service reserve, and in some cases may almost take the place of an air force, in which case it appears, to the supporters of the policy, reasonable that it should be completely under the control of the State.

The first object to be achieved if commercial aviation is to evolve and attain its maximum of utility as a means of rapid transport, is that it should arrive at the stage at which it can pay its way in the shortest possible time. This demands the practice of the most rigid economy, coupled with and balanced by efficiency. Government systems of finance do not lend themselves to economy in the operation of undertakings of this nature, the overhead charges involved in State administration being out of proportion to the services rendered in comparatively small enterprises. Moreover, air transport being purely a business undertaking like any other form of transport, it is desirable if success is to be achieved that the conduct of it shall be rendered as simple as possible, and that the management shall be free from restrictions other than those demanded by business requirements. This would be practically impossible under State control, since the wheels of Government machinery must, of necessity, move slowly, and in so doing clog the free and fluid action so essential to

the well-being of a business concern, which must at all times be ready to take advantage of opportunities and be able rapidly to alter its methods to meet varying conditions.

To conduct a business with economy and efficiency, continuity of policy is essential, and this is rendered impossible under control by a State in which the system of party politics is in force.

In a later chapter it is stressed that the future of air transport lies along the way of international co-operation. Under State control, in many cases the full benefit and effect of this could not be achieved, since business alliances between companies of two States are frequently possible when political alliances between the same two States are impossible.

Air transport, to be successful, must be operated purely on a business basis, and nothing but business methods must find a place in its organization. Political considerations must be eliminated. Services must be operated only over routes which are likely to show a sound financial return, and no other aspects must be embraced in the policy of its development. It is true that at the present time this principle is not being adopted universally, nevertheless it is equally true that in instances where this policy is not being followed, unless the business advantages derived from the exploitation are commensurate with the political development of these routes, ultimate financial success cannot be secured.

Private enterprise carries with it the obligation of the directors and management to make every endeavour to pay a dividend to the shareholders, which incentive to efficiency is entirely absent in the case of State control.

Looking further ahead to the day when air transport is self-supporting and is in a position to pay interest on its capital without the aid of State subsidies, the great difficulty with which it is faced to-day, namely lack of capital, will be remedied. Then, under private enterprise, routes will be opened and services operated wherever it will pay to do so.

Under State control, however, it is extremely improbable that anything more than what may be called the essential trunk routes would be operated, since with every new service inaugurated, capital expenditure would be required which it would be difficult for any government to provide on an adequate scale.

It is sometimes stated that where a State may desire to maintain a small air force for defence purposes but does not feel justified in expending the money necessary, on which no return is received, it is advantageous for this force to carry out commercial functions as well, and thus contribute towards its cost. In isolated cases this may be possible or even desirable, but in the majority of cases the only result will be an inefficient air force or an inadequate commercial service, and certainly is this so if an air force is utilized for air transport purposes, the prime feature of which is regular and continuous operation year in and year out.

If it is accepted that under State control business cannot be conducted as economically as it can be by private enterprise, it follows that, under the latter system, the time which must elapse before air transport can pay its way without artificial assistance will be shorter than in the former case, and, consequently, the total amount required in artificial assistance will be less when operated under private than under State control. Thus, not only will actual expenditure by the State be reduced, but the advantages to be derived from the economic operation of air transport will be felt at an earlier date.

CHAPTER IV

LEGISLATION

As has already been seen, birth was given to air transport very soon after the termination of the war. Since it was desirable that civil aviation should be put on a legalized footing before active commercial flying commenced, this was effected by the issue of the Air Navigation Act, 1919, and the Air Navigation Regulations dated 30th April, 1919. Until these ordinances were introduced no civil flying was permitted.

Since the first services which were operated ran from London to the Continent, and as it was fully realized that expansion would be by means of prolongation of routes through Europe, it was evident that if each nation issued its own regulations independently of others, only chaos could result, which would render regular operation of air services extremely difficult, if not impossible. In consequence, representatives of the allied and associated Powers appointed a commission which was a sub-commission of the Peace Conference, to study the question of obtaining international uniformity of practice, procedure and legislation, as far as could be done. The regulations which were drawn up by this body are known as the "Convention relating to the Regulation of Aerial Navigation, dated 13th October, 1919," which is generally referred to briefly as the International Convention, or the I.C.A.N. The main subjects dealt with in this convention are—

1. The sovereignty of the air and right of passage by aircraft bearing the nationality of contracting States.

2. Areas over which flight is prohibited.

3. The registration, marking, and nationality of aircraft.

4. The provision of certificates of airworthiness of aircraft and licences of the crews of aircraft, etc.

5. The carriage and use of wireless apparatus.

6. Reservation of internal traffic of a country to its own nationals.

7. The use of aerodromes and conditions applying thereto.

8. Prohibition of the carriage of certain articles by air.

9. The classification of aircraft.

10. Powers of voting on the commission.

11. The collection and distribution of information concerning international air navigation, wireless telegraphy, meteorology and medical science in its relation to air navigation.

12. Customs regulations.

13. Procedure to be adopted in the event of disagreement.

14. Classification of States and their rights with regard to adhesion to the convention.

15. Documents, etc., to be carried by aircraft.

16. Rules concerning lights to be carried and signals to be used in connection with air traffic.

17. Rules of the air and special instructions to be observed by aircraft when in the vicinity of an aerodrome.

18. International aeronautical maps and ground markings.

An outcome of the convention is the formation of the International Commission for Air Navigation. This commission meets twice each year, successive sessions usually being held, in different capital cities in Europe, of States which are members of the convention. At these meetings questions of procedure legislation and regulations are under constant review in order to keep pace with developments, and to make such modifications as experience shows to be necessary.

The secretariat of the commission is permanently located in Paris.

In order that each State which is a member of the

convention shall give effect to its rulings, domestic legislation is required, and in Great Britain this is effected by means of the issue of Air Navigation Directions under authority granted in the Air Navigation Act. These directions are necessarily being constantly revised, in order to keep them in line with resolutions passed by the International Convention, or as progress may demand.

In addition to the rulings of the Air Convention, international conferences are frequently assembled, at many of which States which are not members of the convention are represented. At these, special subjects which fall outside the scope of the convention may be considered, but generally they are confined to the study of practical problems which arise from the operation of particular international routes. When decisions are arrived at which are of sufficient importance to justify it, internal legislation may be introduced to give effect to the decisions, but in the case of States which are members of the convention, only provided that no infringement of the letter or the spirit of the International Convention is involved.

Although having no legal powers, an international body known as the International Air Traffic Association was founded soon after the war. This body is formed of representatives of the various operating companies. Periodic meetings are held in different cities in Europe at which questions are considered which have a direct bearing on the operation of air transport.

Resolutions are passed by this body and where they are of such a nature as to affect regulations or legislation, are usually submitted to the International Convention for consideration.

This body has its permanent secretariat situated at The Hague.

A side of air development which is covered by domestic legislation, but which is not the sole child of either of the bodies so far referred to, is that of private flying,

sporting meetings, and competitions. In the majority of countries this phase of flying is controlled by their respective aero clubs, that in Great Britain being "The Royal Aero Club." These various national clubs are combined in an organization known as the "Fédération Aéronautique Internationale." This body makes rules and regulations regarding such matters as are connected with international records of performance, etc., and issues certificates to the holders of these records. In addition it studies questions which are of universal importance and interest, and frequently makes recommendations through the various aero clubs of which it is composed to their respective Governments.

It will thus be seen that the main objective kept in view with regard to aerial development is to obtain as far as possible international uniformity both in practice and in legislation.

Purely as a domestic matter in Great Britain, there is a further body which plays an important part indirectly with regard to internal legislation. This is known as the Society of British Aircraft Constructors, and as its name implies, its membership consists of the leading aircraft designers and constructors, manufacturers of aero engines, and of component parts of aircraft and engines.

This association, which is primarily concerned with safeguarding the interests of the aircraft manufacturing industry, is of necessity closely affected by legislation which in any way touches on technical development or constructional requirements, and in consequence is invariably consulted before any regulations which have a bearing on this side of aeronautics are brought into effect.

Although a considerable amount of progress in commercial aviation is taking place in countries in Europe which are not yet members of the International Convention, uniformity of procedure is generally obtained as a result of the natural desire of these countries to fall into line with systems and legislation as adopted by the majority. Further, as an outcome of air traffic agreements which are

entered into, either between these countries, or between one country which is a member of the convention and one which is not, a considerable measure of standardization is obtained, since all these agreements are drawn up so as to conform as far as possible with legislation and practice as laid down by the International Convention.

CHAPTER V

GENERAL PRINCIPLES

THE problems connected with the operation of air transport services are innumerable and, generally, it will be found in the study of any particular scheme that conflicting issues arise, which it is necessary to weigh carefully in order to arrive at a just balance.

Regularity, reliability, and safety, may be taken as the watchwords to be applied to commercial aviation. These three factors are to a very great extent dependent on the efficiency with which the ground organization of an air route is provided, therefore let it be regarded as an axiom that the first essential for the successful operation of air transport lies not in the air, but on the ground. The various items which in combination make up ground organization have not yet reached perfection, nevertheless much has been achieved since the first commercial services started in May, 1919, and steady and rapid progress is being made. The main items which are included in the general term "ground organization" are aerodromes, landing grounds, wireless and meteorological services, lighthouses and light beacons, aerodrome and obstruction lights, fog signals, hangars, workshops, stores, offices and quarters (where these are necessary), and customs and immigration facilities.

In studying the possibility of the operation of services on any particular route consideration must be paid to the following points—

1. The time which can be saved over existing means of transport.

2. The traffic already existing on the route.

3. The proportion of such existing traffic which may be attracted to the air.

4. New traffic which may be created.

5. The nature of the terrain to be operated over.
6. The meteorological conditions to be met with.
7. The length of non-stop stages to be flown.
8. The frequency of the service.
9. The cost of labour, imported or native.
10. The cost and supply of fuel.
11. Customs duties and local taxation.
12. The difficulties involved in salvage.
13. The best position for the establishment of the operating base.
14. How the service will connect with existing forms of transport.
15. Local legislation.
16. Subsidies which may be available.

Other points may arise for consideration in particular instances, but generally speaking, as a result of a close study of the conditions included in the above headings, it will be possible to indicate with regard to a particular service—

1. Whether it shows a reasonable prospect of being or becoming a sound financial proposition.
2. The type and number of machines to be employed.
3. The method of operating the route, for example the number of services per day, per week, or per month, the position of the operating base, intermediate stations, etc.
4. Whether day or night services or a combination of both should be instituted.

Aviation, supplying as it does a rapid means of transport, the speed of which is so far in excess of anything which exists in any other means of transit, is ideally suited for operation over long distances, especially where either no facilities for transport exist, or where the needs of civilization and commerce are badly served, for here obviously the greatest advantage will accrue. These conditions may be sought where the only existing form of transport is by sea or where rail communication is carried out by circuitous routes.

It may then reasonably be asked, why the operation of

air transport is mainly confined to Europe, which is well served with fast rail communication? This is purely a passing phase in the evolution of an industry which has had an abnormally rapid growth. But that progress has been so amazingly swift is largely to be accounted for by the very fact that the primary work has been carried out in Europe. Here the weather conditions are as bad or worse than are normally to be met with in any other part of the globe, here highly organized transport already exists, and here the travelling public has to be inveigled away from the form of travel with which it has grown up, and which in consequence it regards as a normal part of its daily life.

Air transport has consequently had to establish itself in a hard school. It has had to struggle to bring its equipment to the highest pitch of perfection possible in the short time available. It has been necessary to evolve instruments, devices and methods of navigation, in order to render it capable in large measure of defying the elements. It has had to provide comfort of travel and prove that it is safe and reliable, and to overcome the natural prejudice of the average person to leave *terra firma* and embark on an unknown undertaking. While it is true that it has not achieved perfection in all these things, it has made very great progress towards it.

The great strides in the development of air transport which have been made as a result of the operation of European services are also due to the fact that they have been carried out where the designers of the aircraft, engines and equipment, have been able to keep in the closest touch with their products. It has consequently been possible for them to discuss with pilots and personnel on the spot, weaknesses, failures, shortcomings and defects, which have come to light as the result of constant daily use.

They have thus been enabled to bring about modifications and improvements in a manner which under other circumstances would obviously have been impossible, except by a lengthy, costly and greatly delayed process. Moreover,

operators have had the enormous advantage of being able to discuss problems and difficulties as they arose with the most enlightened technical brains of the day. This has not only been of the greatest assistance to themselves, but also to the development of aeronautical science.

These home services may therefore be regarded largely in the light of schools in which the most valuable lessons are both being taught and learnt.

It must not, however, be imagined that the European services will continue to act only in the capacity of practical scholastic establishments. At no far distant date the main Imperial and world trunk routes, with which the European services will connect, will be opened radiating from Europe, Berlin and Vienna in all probability being the main focal centres.

Further, as soon as the present difficulties of flying in fog and the difficulties connected with the operation of regular night services have been overcome, there will be a real and useful saving of time involved in operating any service beyond a distance of approximately 300 miles, even in competition with the existing highly organized rail services.

Under present conditions, as long as subsidies are indispensable in order to assist air transport through the stages of infancy and the ailments inherent thereto, it is clear that development must take place mainly on national lines. This, however, is a passing phase. In a continent such as Europe where the countries comprising it, with the exception of Russia, are all small, when considered aerially, development must tend to become international. From the point of view of air transport, frontiers may be said hardly to exist; for example, an aircraft leaving England for Sweden, passes from England through France, Belgium, Holland, Germany and Denmark to Sweden, a journey which is on one of the scheduled routes, and is accomplished between breakfast and dinner in the same day. When consideration is given to the fact that in each of these countries there is either one or more operating

companies, each of which depends for its existence on flying beyond the borders of its own country, it is clear that useless and unprofitable competition must exist. Competition is essential if an industry is to be maintained in a healthy state, but this can be provided by the rival operation of alternative routes.

The seeds from which international aviation will grow were sown when the International Convention for Aerial Navigation and the International Air Transport Association were founded. The former, a purely official organization, on the commission of which only Government representatives sit, exists for the purpose of drawing up and instituting standard systems for rules of the air, ground organization, route lighting, wireless and meteorological services and procedure, customs regulations, safety regulations, airworthiness, etc., while the latter is concerned entirely with standardizing operational procedure. As a result of the formation of these two organizations, legislation and practice is evolving on similar lines throughout the greater part of Europe, and as soon as the operation of services becomes a paying proposition it will become simple and a natural development for the existing companies, gradually to be amalgamated into international organizations. The control and operation of traffic will be simplified thereby, while the elimination of ineffective services and the wise distribution of aircraft will lead to economy.

Like all pioneer enterprises, the expansion of aviation is severely hampered by financial stringency.

No development can take place on a large scale until the necessary capital is forthcoming, and this will not materialize, unless a long view is taken, until it is proved that air transport is actually paying its way. This cannot occur until the expenses entailed in operation are reduced.

There are many factors at the present day which contribute towards the maintenance of high costs, the most important of which is lack of intensive operation. The reason for this is not far to seek. Aircraft can only be used

to their full capacity if traffic is forthcoming in sufficient volume to provide them with a reasonable load. Until this occurs the whole of the overhead charges involved must be distributed over a moderate number of services, and in consequence, every passenger or pound of goods has to pay an unnecessarily large proportion of these charges. As traffic increases, costs will fall automatically, and the time is not far distant when air transport will be regarded as a reliable investment.

Before that time arrives, however, a difficult path must be traversed. No sudden and vast increase in traffic will be forthcoming until charges are reduced, and charges cannot be reduced until the traffic is forthcoming. There are two ways in which this vicious circle can be broken; one is by the process of gradual evolution, and the other by adopting a bold policy of fare reduction in order to make air travel sufficiently attractive to the masses. The latter course would probably prove to be the more economical in the long run and would undoubtedly achieve the desired result in a shorter space of time. Such a policy, however, requires the support of capital and until this is available, no alternative remains but to accept the slower means of attaining the same goal.

CHAPTER VI

BASIC PRINCIPLES OF THE OPERATION OF SERVICES

THE first and prime factor in air transport, which must be regarded as the basic principle of operation, is the intensive use of the aircraft. In this respect, at any rate, the problem as to how to employ the vehicle, whatever it may be, whether ship, train, motor lorry or aeroplane, so as to obtain from it the maximum number of hours work in any given period, puts air transport on the same footing as every other form of transport.

One very obvious fact which appears frequently to be overlooked is that a fleet of aircraft represents capital. Capital lying idle cannot earn dividends and, consequently, it is clear that the fleet which represents so much capital must be worked to its fullest capacity. It is equally obvious that since the expansion of a business normally requires the provision of new capital, it is essential, if the application of air transport is to be extended, that it must be put on a paying basis within the shortest space of time possible, as new money will not flow into any industry unless, under normal trading circumstances, a return in the form of interest on the capital invested can be assured.

To work aircraft intensively, certain conditions must exist. Firstly, the route to be operated must either be of sufficient length to keep the aircraft working it fully employed, or if of short length, produce sufficient traffic for the aircraft to operate backwards and forwards more or less continuously. Secondly, the organization of a transport company must be laid out in such a manner that machines, while being thoroughly and efficiently inspected and, when need be, overhauled, can be dealt with expeditiously.

Under conditions generally prevailing in Europe at the present time, intensive operation means utilizing as many hours of daylight as possible for flying, while inspection,

repair and overhaul, is carried out at night. This is not an ideal condition, since repair and inspection work can be more quickly and thoroughly carried out in day time than by artificial light and, moreover, night labour is more expensive than day labour. The ideal condition, then, would be to concentrate the greatest number of flying hours into the night and part of the day, using the remainder of the day for inspection and overhaul. Such a system of operation would not only bring about an economy of operation but over long routes would effect the greatest saving of useful time, both for passengers and mails. For example, a night service from London to Berlin could be accomplished between the hours of 7.30 p.m. and 4.30 the following morning with an extension to Moscow by 8.30 the same evening, that is to say, that the journey from London to Moscow could be made with the loss of only one working day.

There are two main reasons why such services are not the normal practice at present; firstly, the ground organization, except here and there, is not sufficiently perfected for regular night operation, and secondly, only a very small percentage of the public has developed an air sense to an extent which would induce them to make use of night services. This, however, is merely a passing phase.

On the shorter routes only by frequency of service can machines be used to their fullest capacity, but in order to warrant a frequent service it is necessary that a sufficient volume of passengers, goods, and mails is forthcoming; and, in addition, that the traffic is distributed throughout the day. This stage has not yet been reached on the London-Continental airways, where the majority of the passengers desire to travel about midday, and only a limited number of mail dispatches take place.

Here let it be remarked that mere unqualified statistics are sometimes misleading. For instance, returns of travelling public which only show numbers may indicate a steady increase, but if this increase is all centred round about a

popular hour of travel, no economic advantage is gained in transporting them, since the number of machines to cope with the traffic must be increased, instead of it being possible to increase the number of flying hours per machine by a more equal distribution of the travellers throughout the day. Where an increase in traffic occurs in one direction it may happen in the reverse direction at about the same hour, thus calling for a large number of machines, all of which are in operation for a short period with only a small chance of obtaining remunerative return loads.

Only by the slow process of gradual education of the public to the advantages which accompany the use of air transport will these difficult problems be solved. As the travelling public makes more and more use of the air services and as these become, in increasing measure, a regular feature of daily life, then only will a more even distribution of passengers be obtained. Looking at this question of even distribution of services and intensive use of aircraft from another aspect, it will be realized that since the overhead standing charges involved in the operation of air transport may amount to as much as 75 per cent, or even more, of the total operating costs in cases where only a limited number of services are running, the remaining 25 per cent being due to pure running costs, the surest way of bringing about a more even distribution of the two classes of cost which make up the total is to increase the services, and consequently the running costs, to the highest point which it is possible to do without an increase in the standing overhead charges. For all practical purposes this means running the machines to their maximum capacity. Let us here consider a purely imaginary case and see what is the effect of intensive versus non-intensive operation. Assuming that on a certain route over which a service is operated once daily in each direction, and on which each machine flies on an average six hours per diem, the running costs amount to 25 per cent of the total operating costs, which for sake of example may be put at £100 per diem,

then the standing overhead charge will amount to £75 and the running costs to £25. Now assume that the same route is operated on the intensive system to the extent that each machine averages eighteen hours flying per diem, the standing overheads will still amount to £75, while the running charges will have risen to £75, making a total of £150 per diem. For this £150, three return services per diem will be flown, or each return service will cost £50 per diem as against £100 per return service when operated under the non-intensive system. It is obvious that, in actual practice, the results would not come out quite as simply as here stated, but the example gives a sufficient indication of the general effect which will be produced when real intensive operation becomes the normal method of working air transport. Now let us go a step farther. An increase in the number of machines in a fleet does not increase the standing charges in direct proportion, and the bigger the aircraft operating organization becomes, the smaller will be the proportionate increase due solely to additions to the fleet. Consequently, it follows that when traffic is forthcoming in sufficient volume, while at the same time being equally distributed over the twenty-four hours of the day to permit the employment of machines in increasing numbers which can be intensively used, the costs of operation will fall, when the charges made for transport will be automatically reduced.

This line of argument naturally leads to consideration of the development of Empire routes and colonial development. If the panacea for the high cost of air transport is intensive operation, it may be argued, how will it ever be possible to bring about a reduction of costs in territory which, comparatively speaking, is only sparsely populated? On the trunk Imperial routes, intensive operation will be provided by the length of line, and increase in fleets will be brought about as the advantages to be gained by making use of rapid means of transport become fully appreciated. On these routes a vast volume of traffic already exists, a

very small percentage of which, when diverted to air transport, will provide the means by which it can be put on a self-supporting basis ; moreover, since the advantage to be gained in the saving of time over these long routes is so great, the traffic can stand comparatively heavy charges. This is not the case over the shorter routes in Europe, which are already supplied with good and comparatively rapid means of communication, where the charges must bear some relation to fares levied by the older systems of travel either by sea or land, with which air transport is rapidly becoming, if not a serious competitor, at least a factor which must be considered.

Services in the colonies and in more or less undeveloped territory, in some cases, even to-day, supply the only practical means of communication. Here the conditions are entirely different from those which exist in thickly populated countries already well supplied with communications, or on the trunk Imperial routes which are only waiting to be developed. Where there is no form of regular transport other than, for example, canoe, pack animals, or porters, and where a journey which takes, say, three or four weeks, or even months, may be carried out by air in as many hours, it is manifest that air transport is in a position to charge fares which would be unreasonable in other parts of the world, and yet effect a saving in expense on a journey. Under these conditions services must be limited and the corresponding cost of transport must be high. In such territories other work could generally be combined with transport, such as air survey, taxi work, etc., which assist in reducing costs, but are unlikely to assist materially in balancing expenditure. This case, however, is analogous to the opening up of new territory by railroads, on which no return is expected during the years which pass while the country is in the process of colonization and development.

Here, air transport can, and will, undoubtedly fulfil a most important rôle, by keeping those far-away districts in

touch with the world, supplying the scattered inhabitants with the necessities and some of the comforts of civilization, bringing them medical aid when sorely needed and, in general, by supplying a link with the outside world. This aid to development can be provided at a ridiculously low cost, but no return on the capital laid out can be expected in the early days. The value of aircraft to colonization and as an aid to pioneer development has not yet been appreciated. Its opportunity will come, and when it does, let it not be thrown aside because it cannot pay its way. Under these conditions, regard it as what it is, namely, as an ideal method of opening up new territory at the minimum cost. It will reap its reward in the years which follow.

CHAPTER VII

ECONOMIC FACTORS IN THE OPERATION OF SERVICES

IN the preceding chapter, great stress was laid on the advantage to be gained by the intensive operation of aircraft. Now let us consider in some detail the main items which figure in the balance sheet of an operation company.

These fall under two headings, namely, "Standing Charges," in which category are placed all charges and costs which are independent of the actual hours flown and must be borne whether a large or small amount of flying takes place; and "Running Costs," which comprise those charges which are directly dependent on the amount of flying done. Perhaps the clearest way of indicating the main charges which are relevant to air transport under their respective headings will be to set out a statement of the items as follows—

ANNUAL EXPENDITURE

Standing Charges.

Insurance of aircraft and engines complete.
,, ,, spare engines.
,, ,, equipment.
,, ,, buildings, plant, etc.
,, ,, motor transport.
,, ,, personnel.

Depreciation of equipment.
,, ,, buildings, plant, etc.
,, ,, motor transport.

Obsolescence of aircraft and engines.

Rents, rates and taxes.

Housing fees.

Office expenses, postage, telegram and telephone charges.

Lighting and power.

Cartage, travelling and salvage charges.

Advertisement.
Directors' fees and legal expenses.
Salaries and wages.
Sundry trading expenses.
Interest on capital.

Running Charges

Petrol and oil.
Maintenance of aircraft and engines.
,, and running of motor transport.
Pilots' and mechanics' flying pay.
Wireless charges.
Landing fees.

When a company is operating regular services it is customary to pay a composite yearly rate to cover landing and housing fees, in which case the former charge will be included under the heading of " Standing Charges," and can consequently be omitted from " Running Charges."

Under the heading of "Standing Charges," the heavy items of expenditure are—

Insurance of aircraft and engines.
Obsolescence of aircraft and engines.
Salaries and wages.

With regard to insurance of aircraft, the percentage rate varies according to the type of machine used, the nature of the country operated over, the meteorological conditions existing, the system of maintenance and inspection employed, and the ability of the pilots. In addition to this there is at the present day another factor which has an important bearing on insurance rates as a whole, which is the limited field, comparatively speaking, over which risks can be spread. As the number of aircraft in regular operation increases so the field for insurance will increase, with a consequent natural fall in prices.

Given a thoroughly sound operating organization, the factor which plays the most important part in insurance rates is the type of machine used. For example, a single-engined machine of sound and reliable construction may

call for a rate varying from 12½ to 25 per cent per annum, or even more, whereas an efficient three-engined machine, operated by a reputable company, may cost only 7½ per cent per annum. These rates may be obtained at the present day, and may be expected to be materially reduced as the market for aviation insurance widens.

Another factor which bears considerably on insurance rates is whether aircraft are operated as land machines or sea-going craft. This is obvious, since with the marine type of aircraft, the whole of their routes, lying as they normally do over water, are provided with a natural emergency landing ground from end to end, always assuming that the aircraft concerned is a seaworthy machine. Then again, an important consideration which weighs with aircraft insurance underwriters, is the ease with which aircraft can be repaired in the event of damage. Obviously a machine which, from its form of construction, is costly and difficult to repair, calls for a higher insurance rate than one of which the converse is true. The influence on rates due to the nature of the country on any particular route, the prevalent meteorological conditions, the system of maintenance and ability of the pilots employed, are too obvious to need any explanation.

Now let us consider for a moment the issues involved in obsolescence. The present-day aircraft, while being a decided development on the majority of machines which were designed purely for air transport purposes at the commencement of its era in 1919 and 1920, have still only advanced a small stage on the road of evolution.

The three-engined machine is now coming into its own; metal construction is in the early stages of application to air transport; the air-cooled radial engine is in its early days; and the size and carrying capacity of machines now are not much greater than they were six years ago. Nevertheless, advances such as they are, are all tending to reduce operating costs, and it is well within the realms of possibility, and even of probability, that the machine of to-day

may be obsolete two or three years hence. Provided that the anticipated development of air transport takes place, and that extensions to existing routes, or even entirely new routes are opened, there will still be an opportunity to utilize somewhat out-of-date machines during the early days of operating such routes, always assuming that the machines are suitable in the first place.

No prudent concern equipped with present-day aircraft could, however, base obsolescence charges on a longer life than five years, in other words, the value of aircraft must be written down annually at a rate of 20 per cent. At the end of five years, an aircraft of sound construction which in the meantime has been efficiently maintained, would still possess a residual value, but it is doubtful if it would be possible to realize it practically. This charge of obsolescence raises one of the most difficult problems for consideration in connection with the present-day operation of air transport. So long as extensive developments in the design of aircraft are likely to occur, these charges must be faced, and constitute an additional reason for the system of intensive operation on which so much stress has already been laid.

While dealing with this subject it may be as well to mention here, that in respect to aircraft operation, obsolescence replaces depreciation, provided that maintenance is effectively and thoroughly carried out. Even under the best organization the effect of depreciation would become evident in course of time, but since this time would not be reached before the expiration of the full period allowed for obsolescence, no consideration need be given to it except to the extent, possibly, of making each year an increasing allowance for maintenance charges. It is considered improbable that this would be necessary with all metal aircraft, but there is insufficient data yet available on which to base a definite conclusion.

The item of expenditure due to salaries and wages requires little comment. There is, however, one aspect

which deserves consideration. In a previous chapter it was explained that there are two alternatives, by either of which intensive operation can be achieved, namely, by flying over long routes or by running frequent services backwards and forwards over short routes. The former necessarily calls for the establishment of a number, either of main or subsidiary stations, which involves the employment of personnel at each of them, and incidentally of aerodrome equipment additional to that which would be required when operating intensively over a short route.

Dealing now with "Running Charges," the main items of expenditure are centred in fuel consumption and maintenance of aircraft and engines.

Fuel consumption depends mainly on the horse-power of the engines employed, and varies only slightly per unit of power output with the design or type of engine used. This is true with the several types of petrol engines as now in use, but will not necessarily continue. Economies which may possibly be effected by the introduction of entirely new designs of engines are dealt with in Chapter XVI.

Maintenance constitutes one of the heaviest items of expenditure in the operation of air transport. Even the very best and highest pitch of efficiency which can be obtained is not good enough. The nearest approach possible to absolute perfection is essential, and this obviously costs money. Economy under this heading cannot therefore be obtained by any reduction in efficiency, and must be sought for and effected by faultless organization based on a thorough and sound system.

It cannot be too forcibly stressed that, apart from ground organization, reliability in the operation of air transport is almost entirely dependent on efficient maintenance, and consequently, anything short of perfection in this respect is false economy. It must be remembered that a lack of reliability has a repercussive effect on insurance rates; interferes with the regularity of services, thereby affecting receipts; upsets routine methods of working; and destroys confidence.

A brief study of this question of cost of operation makes it abundantly clear that many factors are in opposition to each other, and that a careful balance must be struck between the various advantages and disadvantages. For example, insurance and obsolescence, both serious items of expenditure, are directly dependent on the capital cost of the aircraft and engines used; cheapness of aircraft may, therefore, appear at first sight to be a primary consideration; against this, however, it may well be that the costs of maintenance may be so much greater of a cheap aircraft than of a more expensive one, that the advantages obtained over lower insurance and obsolescence charges may be outweighed by higher maintenance costs. These and many other problems of a similar nature are continually arising in the study of air transport, and require very mature consideration in order that a sound conclusion may be arrived at.

Leaving the items which figure in the balance sheet of an air transport organization, let us consider some of the further factors which affect the cost of operation.

Perhaps the most important of these is the paying load per unit of horse-power which a given aircraft can carry. It has already been stated that fuel consumption is almost entirely dependent on horse-power, consequently the greater the load which can be carried for a given horse-power, the cheaper the cost of operation becomes. Then again, the smaller the quantity of fuel which is consumed for a given output of power, the smaller is the amount and consequently the weight, of the fuel which has to be carried to fly a given number of hours, and therefore, the greater the useful load which can be borne. Designers are constantly endeavouring to improve the useful load per horse-power which can be carried. This, however, is not the only consideration; speed is also a most important factor in operational expenditure, since it directly affects the load per horse-power which can be carried. It may be accepted as a fact that, with aircraft as designed to-day, the load

which can be carried for a given output of power is largely dependent on the speed at which it is carried. At the same time, speed affects cost in another way because the hours spent in the air are dependent on it. The distance flown is only directly concerned in so far as it affects the hours flown. Consequently, the greater the speed, the smaller is the time taken to fly between two given points and, therefore, the lower will be the cost.

Economy due to speed will only be achieved, however, if the speed for a given load is increased without a corresponding increase in horse-power. It follows, therefore, that the goal to be aimed at is the use of aircraft which can carry a heavy useful load at a great speed with the minimum use of power, since each of these items has a direct bearing on cost. Here, again, a nice judgment and discretion is needed to decide to what extent any one of these items must be sacrificed to the other two.

The economic aspect of air transport is a mass of contradictions which can never be entirely removed. Nevertheless, improvement in the performance of aircraft will assist in finding a solution to the many difficult problems which are inherent in its operation.

CHAPTER VIII

GROUND ORGANIZATION : LAYOUT OF A TERMINAL AERODROME

THE term, " Terminal Aerodrome," is generally applied to the aerodrome which serves the capital city of a country at which the headquarters of the national air transport companies are normally located.

In the case of England, this station is known as the " London Terminal Aerodrome," and is situated near Croydon.

The ideal terminal aerodrome would be close to the heart of the city which it serves, but in most cases this is rendered impossible owing to the large open space which is required. Berlin provides the best example to be found in Europe of a well-sited terminal aerodrome. This was rendered possible by the existence of a large, flat, open space which before, and during the war, was used for military parade and review purposes. It is less than ten minutes' drive by car from the centre of the city, with which it is connected by good main roads.

In the event of its being impossible to find a suitable site near the centre of a city, the next desirable condition is that it shall be provided with good communications, either by road, rail, tram or bus, and preferably by all four of these means.

One condition which has most seriously to be considered before a site can finally be settled upon is the possibility of its being affected by fog, the bugbear of aviation at the present day. It is well known that certain areas in proximity to big towns are always more liable to fog and smoke pollution than others, owing to such varying factors as prevailing winds, low-lying or marshy ground, the existence of rivers or lakes, the neighbourhood of large industrial plants, etc.

The London Terminal Aerodrome is far from ideal, in that it is approximately thirteen miles from the centre of London, and is extremely badly supplied with means of ground communication. Against this disadvantage, however, must be set the important fact that in an area which is very frequently blanketed by fog, the aerodrome is placed where the least ill-effects from it are experienced.

Where any choice can be made, other things being equal, it is preferable to lay out the aerodrome on the side of the city on which the majority of the air routes operate, in order to avoid as far as possible flying over thickly populated areas.

A terminal aerodrome should be flat, with a well-drained soil which is unlikely to become boggy after heavy rain. Under existing conditions it should be not less in size than 800 yards by 800 yards, preferably larger. The surroundings should be as free as possible from obstacles such as trees, high buildings, telegraph wires, etc. Where these conditions are impossible to find, which is the rule rather than the exception, a good run, clear of all obstructions, should exist in the direction of the prevailing wind.

The buildings which a terminal aerodrome requires consist of hangars, workshops, stores, housing for generating plants, transport sheds, administration offices, wireless and meteorological establishments, customs offices and bonded stores, and offices for the immigration authorities. In addition, hotel accommodation, refreshment and waiting rooms are provided for travellers.

The ideal layout for an aerodrome is to site the main block of buildings according to their purpose in the centre of the aerodrome, surrounded by the hangars for the accommodation of aircraft. The object of this arrangement is that unnecessary taxying is avoided, which not only saves wear and tear of machines, but also the unnecessary use of fuel. At the same time such an arrangement keeps the landing area clear for incoming or outgoing

Fig. 3. The London Terminal Aerodrome, Croydon

machines owing to lack of interference from aircraft manoeuvring on the ground. One great drawback to this system is that it is necessary either to have an access road running across a part of the ground which is used for flying, which is both dangerous and inconvenient, since it tends to cause delays, or alternatively, to construct a tunnel road under the aerodrome, which is extremely costly. The advantages of such a system far outweigh the disadvantages, but the main obstacle to its adoption is the large area of ground which is required, since it must be of sufficient dimensions to give a clear take-off run in any direction, starting straight away from the departure platforms. Consequently it is the normal practice to group all the buildings together on one side of the aerodrome where adequate approach facilities by road exist.

The latest type of hangar which is being constructed, has a doorway opening of 150 ft. This is to allow for the housing of machines which it is anticipated will have a span approaching this size in the not far distant future. The depth of the sheds is also 150 ft., and behind these, and adjoined thereto, are workshops, offices, stores, etc.

An up-to-date aerodrome layout includes a main block of buildings which provide accommodation for the reception of passengers, for waiting rooms, refreshments, newspaper stalls, booking offices. Here will be found facilities for the examination of passengers by the immigration authorities, and the inspection of baggage by officials of the customs department. Under the same roof, offices will be set apart for administrative purposes. The meteorological and wireless staff also will be provided with the accommodation necessary for housing their installations, and for carrying out their proper functions. In addition to all these, and perhaps of the greatest importance, is the office of the Civil Aviation Traffic Officer on duty. This is known as the "Control Tower," and is so situated that a clear view is obtained over the whole expanse of the landing ground. This forms the nerve centre of air traffic, here all messages

are dispatched to and received from aircraft in flight, by means of wireless. Here the positions of all aircraft are recorded or calculated according to the circumstances, and from here instructions as to courses to be followed, information concerning weather conditions, special traffic instructions, etc., are transmitted. Permission to depart or to land is issued from this tower, in fact, it is, as its name implies, the actual control centre for all air traffic within the limits of the area for which it is responsible.

An essential part of the equipment of every aerodrome is an indicator which will show pilots when in the air the direction of the wind either in daylight or darkness. This may consist of a big arrow pivoted so as to be free to revolve under the influence of the wind, and which is painted white to show up clearly by day and has some form of illumination for night work. This is frequently replaced by two separate devices, one to act as an indicator by day, and the other by night. As regards the former the most usual type is an elongated tapered linen tube, flown from a mast erected on the highest aerodrome building, which, when blown out by the wind, is visible from the air owing to its shape. For night work, several types of wind indicators are employed, one of which has already been mentioned. Another form is to have sunk flush with the ground a series of electric lights covered with thick plate glass. These are so arranged that by connecting up different electric circuits a letter in the shape of a capital "L" can be illuminated, the long arm of the "L" being parallel with the direction of the wind, the short arm being at the end from which the wind is blowing. These are either controlled by an automatic contact actuated by a wind vane, or by hand-controlled switches. The same system is sometimes employed, the electric lights being replaced by burning flares which are put in position by hand, as, and when required. The disadvantage of this method is that every time the wind veers, each of the flares has to be moved, which is a laborious business. Still another method is to illuminate with powerful

searchlights a path on the aerodrome, down which the aeroplane must land. This method necessitates either the installation of a series of fixed searchlights round the perimeter of the landing ground, or mounting a searchlight on a travelling carriage.

At the present time, in normal practice, no single one of these methods is used alone, but a combination of two or more is generally adopted.

For assistance in landing at night, some form of ground illumination is invariably employed. The one most frequently met with is a form of that already referred to for indicating the direction of the wind by means of searchlights. A light of very high power is used for this purpose, which is distributed horizontally over a wide arc, approximating 180 degrees, the vertical limit of which is sharply defined, so that by elevating or depressing the housing lantern, the line of demarcation between light and darkness can be raised or lowered. In this manner it is possible to concentrate the maximum amount of illumination where required, and definitely to control the beam so that the dazzling of a pilot can be eliminated. This is known as flood-lighting.

It has now become the usual practice to mark the perimeter of the best landing area with red flashing lights mounted on white pillars. By day the pillars are distinctive, and the red flashing lights clearly indicate the limits of the landing area by night.

All obstacles, such as roofs of buildings, bad ground, wireless masts, obstructions of any nature, are marked by red lights during the hours of darkness.

Main aerodromes are almost invariably equipped with some form of lighthouse or light beacon, each having a characteristic flash, in order to indicate which aerodrome is which. The latest type, which has proved most successful on account of having a long range of visibility in fine weather and an excellent fog penetrating effect, is known as the Neon beacon, so named as it is composed of vertical

tubes of Neon light, each 20 ft. long, arranged at regular intervals round a conical shaped tower.

Many wireless and lighting devices designed to improve aerodrome equipment, especially with regard to the simplification of night and fog flying, are in the experimental stage, and are dealt with in detail in other chapters.

CHAPTER IX

GROUND ORGANIZATION: METEOROLOGY AND WIRELESS SERVICES

THE ground organization of a regular air route is a hydra-headed subject, one of whose faces confronts one in a number of different chapters of this book. In the last chapter, one considered the organization necessary at a terminal aerodrome. In the chapter on Navigation, one faces another aspect, while "night flying" is a problem which is more than half solved by adequate ground organization. "Traffic control" again brings one to the same subject from another side.

It is matter for little wonder then that it has been said, "An air line is on the ground." In present conditions, it is largely true. In the near future, it may become more true. The danger of such a neat epigram lies in its being accepted as a fundamental truth, within whose limits lies the goal. The contrary rather is true. The aim must be to lift the air line off the ground. In the air lies safety! It is only when the aeroplane approaches the ground that the element of risk creeps in. Let us, therefore, aim at reducing these occasions to the necessary minimum.

The object of these generalizations may not be too clear without an illustration. One shall suffice. In an excess of enthusiasm for the broad and easy way to apparent success offered by ground organization, it has even been suggested that an air route should be a continuous landing ground, and, much more frequently, that the whole route should be marked as a visible track along which the pilots should fly. Without such an inducement, we at present suffer from its defects, when pilots are forced to fly beneath low cloud, among tree-tops, hills, church spires, and wirelessmasts. What, then, would be the state if we organized our air routes on the principle that they should do so?

When it is safe and practicable to fly above and not below low cloud, we shall have advanced a long way towards our goal. Comfort and safety here go hand in hand. An aeroplane is meant to fly, and it has the whole of the air to fly in. By a wrong use of ground organization we clip its wings and condemn it to a slavish following of the railway train.

Meteorology and wireless are the two sister services, having their roots on the ground, which will contribute the greatest share towards putting the aeroplane into the air and keeping it there. These subjects, then, occupy the chief place in this general survey of the ground organization, which is not more specifically dealt with in other chapters.

WIRELESS

The function of the wireless service in air transport is threefold. The first is to maintain communication between the aircraft and the ground, and between aerodromes for the purpose of traffic control; the second function is that of a handmaid to the meteorological service in the collection and distribution of reports; the third is to assist in the navigation of the aircraft by means of radiogoniometric bearings and fixes.

In the carrying out of these tasks, the wireless services of Great Britain, France, Belgium, and Holland, have been co-ordinated, in so far as they are concerned in the operation of air transport within the area—London, Paris, Cologne, Amsterdam, London. Full details of the organization and procedure are given in the " Air Pilot Appendix, Parts I, II, and III."

Several wavelengths are allotted for aircraft work. For communication between aircraft and the ground by radio-telephony (telegraphy is not at present used) the band of 850-950 metres is allotted, and the actual wavelength used is 900 metres; this applies for all purposes, including direction-finding. When wireless telegraphy is introduced for certain types of craft, as it is intended to do within

the next year, the wavelength used for this purpose will probably be changed to about 1,550 metres. For intercommunication, such as the passing of traffic messages, between ground stations, the wavelength used is 1,400 metres. For a certain type of meteorological reports known as the "Hourly Route Meteor Messages," which are specially related to air transport, the wavelength is 1,680 metres. Meteorological reports passed to aircraft in flight are, of course, telephonic and on the 900 metre wavelength. Transmissions on all the other wavelengths are telegraphic.

The general W/T requirements of an air route are that the ground stations should be capable of maintaining two-way communication with aircraft throughout the route; that the ground stations should be so linked up with the general W/T organization of the neighbouring world that they can receive all the necessary meteorological reports for the making of forecasts and the passing of route meteor messages; that the terminal stations of stages should be in direct two-way communication with each other for the passing of traffic messages; and that the radiogoniometric service, whether it consists of ground D.F. stations, or of beacon stations for use with radiogoniometers on the aircraft, should adequately cover the whole length of the route with considerable lateral breadth.

The W/T organization in the area mentioned above now practically secures all these services. On the English side of the Channel, Croydon and Lympne are maintained for communication with aircraft and D.F. purposes. Pulham, in Norfolk, is the third D.F. station, while the Air Ministry W/T station handles all the telegraphic portion of the traffic. In France, the service is provided by Le Bourget (Paris), Abbeville and St. Inglevert (near Calais). A D.F. station has recently been established at Le Bourget. Belgium has Haren (Brussels), Ostend and Uccle (Brussels), the latter handling only meteorological reports, while a D.F. station is established at Haren aerodrome. Up to the present a

British station has been maintained at Cologne-Bickendorf aerodrome. Holland maintains stations at Rotterdam and at the Royal Netherlands Meteorological Institute at De Bilt. The latter deals only with meteorological messages; a D.F. station is established at Rotterdam.

For purposes of maintaining communication with aircraft, the terrain is conveniently divided. All aircraft on the English side of the Channel communicate with British ground stations, but those stations keep in touch with aircraft until they have crossed the French or Belgian coast. Similarly, the continental stations concerned maintain communication with all aircraft as far as the English coast. There is a double safeguard therefore for all machines while they are over the Channel.

In order to eliminate unnecessary transmission and jamming of important messages, a definite procedure and routine is laid down. As an example, a pilot bound from Croydon to Paris, calls up Croydon as soon as he has left the ground, to test his apparatus; he reports his position to Croydon at Biggin Hill and when leaving the English coast; and he reports his position to Le Bourget when crossing the French coast, at Abbeville and at Beauvais. Both French and English stations pick up the coastal reports. Other transmissions are normally limited to requests on the part of the pilot for weather reports, and the reporting by him, or to him, of abnormal weather conditions. In thick weather, pilots are also warned of the proximity of other aircraft. Provision is made for the sending of distress signals. The telephonic distress call is the French "M'aidez," phonetically spelt "Mayday" for the benefit of English operators. In the event of a forced landing at sea, provision is made for the aircraft to call up marine stations either ship or shore, on the 600 metres wave. In all communications with aircraft, the letters of the registration mark constitute the call sign, e.g. "G.E.B.B.I.," this call sign being abbreviated to the last two letters after the opening of communication.

The ground stations at Croydon and Lympne are of the Marconi ½ kw. c.w. type, and the aircraft sets at present in use on British aircraft are Marconi A.D. 6 sets, which are capable of both telegraphic and telephonic transmission.

The direction-finding service is to a certain extent covered in the chapter on "Navigation." The ground stations in England employ the Bellini-Tosi system. They are sited so as to secure the best geometrical intersections of wavefront directions on that section of the Continental routes between Croydon and the French and Belgian coasts. To a certain extent the position of Pulham is also governed by the fact that one of the main airship stations is situated there. The existence of D.F. stations on the aerodromes at Croydon and Lympne also enables pilots to obtain with ease in foggy weather the direction to fly to reach one of those aerodromes. While direction-finding for aircraft is normally carried out by the stations established for that purpose, it is possible for aircraft fitted with wireless telegraphic apparatus to obtain on 600 metres, a position or bearing from the marine D.F. stations situated on both sides of the North Sea and English Channel.

While space does not permit of a more detailed account of the organization in a work of this nature, we have attempted to give the essential features of an adequate wireless service for air transport. The wireless service to be established on the Cairo-Karachi air route now being organized, for example, will be an attenuated form of that on the continental air routes. The greatest difference, in fact, will be the introduction of telegraphic in place of telephonic communication.

METEOROLOGY

The perfect meteorological service fulfills two purposes in air transport. In the first place, the meteorologist is called on to observe, tabulate, and study, climatological data, in order that he may advise on the planning of air routes; in the second place, he has to be prepared at all

times to forecast and warn the pilot of the weather conditions he will encounter on the route he is about to fly.

For the first service, the meteorologist has to draw on the data which has been accumulated by observers in past years. This is sometimes adequate, but often, since aviation requirements are peculiar, not so. The meteorologist nowadays, however, can arrange for the taking of such additional observations as will be of value, not only for the day to day forecasting, but for the purpose of local climatology as well. In this way, he prepares to give advice on such points as the siting of an aerodrome, from the point of view of prevalence of fog, local winds, etc.

The second function of meteorology is, from our point of view, more important. The success of the forecasting service may almost be said to depend entirely on the efficiency of the wireless service, from the moment that an individual observer in some remote part of the British Isles or Europe reports a rise of the barometer, to the moment when the pilot is warned that there is a probability of fog over the Channel.

We will again take the London-Continental air routes as the model to exemplify the requirements. The weather of the British Isles and Western Europe is notoriously the most fickle and among the most unsuitable for aviation in the world. The organization which has been built up during six years of experience in these conditions is likely to meet the needs of any part of the world.

The meteorological service is usually a State organization, and in Great Britain it forms an integral part of the Air Ministry. Meteorological stations are maintained at the Air Ministry, at Croydon and Lympne, and at a number of Royal Air Force aerodromes. Reports are also received regularly from a great number of reporting stations throughout the British Isles, and from ships at sea. Quite apart from the needs of aviation, the meteorological reports of all the principal countries in the world are interchanged. Anyone wishing to obtain information as to the details of

this complex organization will find it in a handbook produced by the Meteorological Office (M.O. 252), and published and sold by H.M. Stationery Office. The details of the particular organization for civil aviation are published in the "Air Pilot Appendix, Part IV." As with wireless, this particular organization is a co-ordinated service between Great Britain, France, Belgium, and Holland.

The first link in the special chain forged for aviation purposes is the transmission of the "Hourly Route Meteor Messages." These are sent out from the wireless stations at Air Ministry, Le Bourget, Brussels, Cologne, and De Bilt (Holland), from about 0330 in the summer and 0700 in the winter to about 1630 G.M.T. They relate, in each case, to the weather observations made at a number of places on the air routes. In England, for example, they relate to Croydon, Biggin Hill (Kent), Lympne, Beachy Head, Dungeness and Hythe. The information contained in these messages, and forecasts based thereon, are available for pilots at Croydon and Lympne and the principal foreign aerodromes, either on personal application, or by telegram or telephone, and, more important, on request by radio-telephony from the air.

It is of interest to note the information supplied to a pilot who requests a weather report for, say, Lympne. This he might do through Le Bourget, soon after leaving that place. The information supplied would be in the order —time, place, general weather, visibility and height of lowest cloud. A specimen reply would be ; "1415 Lympne rain 2,000 yd. 500 ft." Information as to the surface and upper winds is also given.

A very important feature of the meteorological organization is the sending of special reports to the recipients of the hourly messages, whenever any important change has taken place in the conditions at certain aerodromes. The aerodromes so covered in England are Croydon, Biggin Hill, and Lympne.

It will not be necessary to labour the point that the greatest hampering agents in aviation are fog and low cloud. These are the phenomena, then, which receive consideration in the special reports. In detail, the reports deal with changes in visibility, changes in cloud, height or amount (low cloud only), changes in precipitation (snow, hail, or sleet), changes in wind force (gales), and the occurrence of squalls and thunderstorms. For example, when visibility decreases, a report is sent when it becomes less than 1,000 metres, and again when it becomes less than 200 metres; when it improves, a report is sent when it reaches 500 metres and remains so for ten minutes. All these reports are transmitted immediately to aircraft in flight.

A further precaution taken to warn pilots of dangerous conditions for landing at certain aerodromes is the display of ground signals along the route. These signals are unfortunately not standardized, and it must be claimed that the British system is the most easily memorized. They are displayed at Lympne, Ostend, Flushing, and Abbeville. Those at Lympne, for example, relate to Croydon, Biggin Hill, and St. Inglevert. The signals consist of a group of letters and figures. A specimen signal read by a pilot leaving England would be "S 10 *," meaning that at St. Inglevert the clouds are below 100 metres, the visibility less than 500 metres, and that snow is falling.

The meteorological organization required on such a route as that from Cairo to Karachi (2,500 miles), is probably less complex than that necessary on the London-Paris route of less than one-tenth the distance. The meteorological conditions in the East are comparatively stable, and in the opening stages of the service there will only be meteorological stations as far apart as the terminals of most of the European routes.

GENERAL

It remains to summarize the ground organization in

concerning navigational dangers on the route. This is a State obligation, as are most of the other services at present. It is, of course, not related to any particular route. The warnings take the form of "The Air Pilot," "Air Pilot Monthly Supplement," "Notices to Airmen," and wireless warnings for urgent matter. This has its counterpart in the marine world in the Hydrographer's Department of the Admiralty, whence issue the "Admiralty Sailing Directions," and "Admiralty Notices to Mariners."

An item of ground organization, which cannot be classed with the above, because all systems are still in the experimental stage, must be noted as an essential to the regular operation of an air route. This is a method of enabling aeroplanes to land safely in fog. The problem is touched on in the chapters on "Navigation" and "Night flying."

One further point must be mentioned, but cannot be classed as an essential. In order to assist the pilot in locating his position, the names of a number of towns in the south of England have been marked on the ground in large white chalk letters. Abroad, the practice has been limited to the marking of aerodromes and landing grounds, which has also been done in this country. At best, the aid given to pilots is haphazard, and the adoption of more systematic methods of navigation will render it unnecessary.

CHAPTER X

TRAFFIC CONTROL

THERE are three problems one has in mind when speaking of traffic control. The first is the general control of air traffic from the point of view of restricting aviation to certain areas, or preventing it in certain limited areas. The second is the more restricted problem of avoiding risk of collision. The third is the necessity of keeping touch with aircraft in the air, for the safety of passengers and general expedition of transport.

The International Convention empowers the signatory States to impose certain restrictions on the freedom of passage of civil aircraft, with the proviso that the restrictions must be applied equally as between the national aircraft of the State, and those of all other contracting parties. The degree to which this right is exercised depends entirely on the individual State, and while it could be applied in such a way as completely to paralyse air transport over the territory of a particular State, in general, it has been employed in a very liberal way. One cannot but think that as air transport develops, as it proves its value, and as the true spirit of aviation becomes more widely spread, the nations of the world will realize that the retention of their sovereign rights does not depend on the imposition of irksome restrictions, and the air will become truly free. At present, there are some countries where this is far from being so.

The convention allows contracting States to prescribe corridors of entry into the country, areas over which flight may not take place, and specific routes to be followed by aircraft crossing the country without landing, as well as aerodromes at which all aircraft must make their first landing, and from which they must take their departure.

The main object of corridors of entry is the prevention of

smuggling. The right to impose them is not now exercised by Great Britain; the whole of the coast is free. In France, the corridor of entry from England is between Étaples and the Belgian frontier. In addition, there are corridors from France into Belgium, into Switzerland, and into Italy, corresponding to all the operated or practicable routes. Holland is a country whose frontiers are free, while Turkey, on the other hand, is one where entry is practically restricted to two points.

Prohibited areas are mainly intended for the protection of fortified zones. There are nine such areas in the British Isles. Flight is, however, permitted over these areas above 6,000 feet, provided that no photography is carried out. The practice varies in different countries. Most countries prohibit the carriage of photographic apparatus entirely. In France, for example, there are no declared prohibited areas, but photography is not permitted without a special authorization. In some countries, a considerable proportion of the country is covered by prohibited areas. Provision is made in the convention for the regulation of flight in the neighbourhood of prohibited areas by means of pyrotechnic signal shells, showing, on bursting, smoke by day and stars by night. If necessary, an aircraft may be ordered to land by this means.

Compulsory routes for aircraft have not been imposed by the more progressive States, though there are some States where compulsory routes are laid down, even for aircraft which land during their passage across the country.

The prescription of aerodromes for landing is less directed towards control than to administration. Some such provision is essential for the carrying out of customs examination of passengers and merchandise.

The foundation on which all measures for the avoidance of collision is based is Annex D of the convention containing the "General Rules for Air Traffic." This is divided into "Rules of the Air," "Rules as to Lights and Signals," and "Rules for Air Traffic in the vicinity of Aerodromes."

The "Rules of the Air" follow closely the rules of the road at sea, and up to the present they have been found entirely applicable. The difficulties are in some ways greater, on account of the much higher speed of aircraft, which, in spite of the fact that aircraft do not at present fly in dense fog, reduces the time for action to much less than that available for a ship at sea. The danger is also increased on regularly operated air routes, where large numbers of aircraft follow practically the same line.

To meet this danger, the routes which are most commonly followed between London, Paris, Brussels, and Amsterdam, in so far as they are definable by reference to landmarks, such as railways, rivers, and canals, have been declared officially recognized routes. These routes are in no sense compulsory, but all aircraft which elect to follow them are obliged to keep them 300 metres on their left. Other aircraft must keep clear. In other words, aircraft must not fly close to, and on the left of an officially recognized route, for they would then be in the path of other aircraft flying in the opposite direction. Similarly, if aircraft find it necessary to cross the route, they are required to do so as quickly as possible, so as to reduce the risk of collision with aircraft following the route in the normal way.

These supplementary rules have been extended in a general way, for the guidance of pilots, to apply to flying generally. It is impossible to define and publish every route followed by aircraft, but everywhere there are certain roads, rivers, railways, canals or stretches of coastline, which lie in a convenient direction and form conspicuous landmarks, and which tend to become regular aircraft lanes. In fine weather there is no danger, and in thick weather the application to these routes of the supplementary rules, eliminates the danger which would otherwise arise. In the same way, a danger arises between two such points as Calais and Dover, a common place for crossing the Channel. The danger of collision caused by two aircraft flying in opposite directions along the direct line between these two

points is removed by requiring each to fly some distance to the right of the direct line. There is an analogous practice at sea; the east-bound and west-bound shipping lanes across the Atlantic are thus separated.

Notwithstanding the comparative immunity from collision so established, research is proceeding on methods of detecting the proximity of other aircraft, so that the pilot may be given an auxiliary sense to reinforce that of vision, and to replace it when it is impaired by low visibility. This will naturally have its greatest use in the vicinity of aerodromes, where it is more difficult to remove the danger by the application of rules.

Freedom from collision at regularly used aerodromes, is secured by the rigorous application of a system of control by traffic control officers. At Croydon, for example, a control tower is installed to provide a clear view of the aerodrome. A chart house, having windows on all sides, has a gallery running round outside it, which is used as a signalling platform. The control tower is connected by telephone with the wireless station, so that the officer on duty is in direct touch with aircraft. In the control tower are fitted all the switches for controlling the lights and signals on the aerodrome.

In the first place, no machine is allowed to take off until it is signalled "all clear" by the traffic hand on duty on the gallery. This man is under the orders of the traffic control officer in the cabin. The "all clear" signal is given by waving a flag, the individual machine being indicated by the display of a disc or the directing of a spot light on to the machine. The machine, having taken off, makes one circuit of the aerodrome, for the purpose of testing its wireless and to ensure that everything is in order before leaving. All circuits are made anti-clockwise, i.e. with a left-handed turn. A second machine is not allowed to take off until the first is clear of the aerodrome.

Aircraft coming in to land make one circuit of the aerodrome to make sure that the aerodrome is clear, and to

give an opportunity to the traffic control officer to issue instructions before its landing. If two aeroplanes are approaching the aerodrome to land at the same time, the one at the greater height has to wait till the other has landed. If necessary, the traffic officer can direct a pilot not to land by firing a red pyrotechnic signal, and indicating the machine intended by flashing its call sign with a visual signalling lamp.

Further, to prevent collision, the regulations provide that no aerobatics shall be carried out within 2 Km. of an aerodrome, and no aircraft shall turn within 500 metres of the aerodrome. All the special rules for flight in the vicinity of aerodromes apply up to a height of 6,000 ft.

The general control of traffic en route, from the safety point of view, has been touched upon in connection with wireless services. It is almost entirely secured by a proper use of the wireless service. The pilot reports his position at certain definite stages of his flight, particularly when commencing and finishing his flight across the Channel. In the control tower the traffic officer keeps on the chart a continuous record of the position of each machine, both from the wireless reports, and, knowing the wind from meteorological data, by calculation of its speed and course made good. In the event of any untoward occurrence, the traffic officer then knows, within narrow limits, the position of the machine concerned. Further, if the visibility is bad, he is able to warn the pilots of two approaching aircraft, of their proximity to each other, so that they may be particularly on the alert.

The control goes further than this. It is frequently used to instruct the pilot of an aeroplane in the air to land at some intermediate landing ground, either to pick up passengers or, for example, because of the presence of fog at the terminal aerodrome.

In the event of an aircraft over the Channel passing the distress signal "Mayday," or if an aeroplane is overdue when crossing the Channel, a general "S.O.S." message

giving all details is broadcast to shipping from the most convenient shore W/T station devoted to shipping traffic, as for example, North Foreland. At the same time, an Admiralty tug, which is always kept in readiness for this duty, is dispatched from Dover to the position of the aeroplane as given by the traffic control officer.

An effective control is also kept on aircraft not fitted with wireless, which may be crossing the Channel. This is done by requiring such aircraft to circle over the coastal aerodromes of Lympne on the English side, and St. Inglevert, or Ostend, or the signal station at Calais on the continental side, both when departing and when arriving. The traffic officers at these places are in communication by wireless telegraphy, and can therefore give the " all clear " when the machine in question arrives, or institute the necessary salvage action in case it should not.

Traffic control for all the purposes discussed in this chapter will always be necessary, but lest a wrong impression should be gathered from the precautions taken to ensure safety, it should be said that in the six years history of air transport, no British civil aircraft has descended in the Channel. A better testimony to the care devoted to the maintenance of engines and aircraft could not be sought.

CHAPTER XI

AIR NAVIGATION

THE principles of air navigation are those of marine navigation; the practice is at present much simpler. The basis of all navigation is the proper use of the compass. One might go further and say that it is the proper use of the magnetic compass, though the gyroscope, the radiogoniometer and other modern developments, threaten at last to end its long reign of supremacy.

To go back to the root of the word, " navigation " means the moving of a ship, but the word has long been used in the more limited sense of the moving of a craft with precision to the place desired. It is in that sense in which we use it here.

Air navigation has been, and is, simpler than sea navigation, because the bulk of flying is over the land, and mainly over land of which some form of topographical maps exists. Moreover, flying is still very much tied to the baser element, earth, and the past and present generation of pilots prefer to keep a visible link with that earth from which they sprang. Map reading has, therefore, commonly been the only form of navigation employed to get to the desired destination. The best of map readers, however, are defeated by weather conditions which bring clouds almost to the ground and reduce visibility to a range of a few hundred yards. The only way to realize this statement to the full is to identify space and time. Then it can be expressed this way: the pilot of an aircraft, in the conditions supposed, can see five seconds ahead of him—perhaps less; a man walking on the ground, in these conditions, can see three minutes ahead of him.

Aircraft to-day are comparatively earthbound; to-morrow, they will be free, as the ship is of the land from which it casts off for a voyage of maybe weeks on the

pathless sea. In that day, the commercial air route will lie in the clear blue above the clouds, and in that day, the whole science of navigation will be practised in the air. In the meantime, though the dangers of pure map reading have already led to its abandonment by all except novices, we compromise.

Navigation strictly comprises certain auxiliary ground services, particularly air lighthouses and wireless direction finding stations, but in view of their importance, these subjects are dealt with more fully in separate chapters.

There are two main processes in navigation, under which all others can be conveniently grouped. These are (1) maintaining direction, (2) fixing position. The first can be done by following a railway, river or road, and the second by observing some recognizable landmark on the map; this method requires no comment, except that it is sound only so long as the right railway is followed. Frequently it is not.

When the compass is rightly used for maintaining the course, a map is still necessary. Without a map, the desired direction cannot even be ascertained. For the time being, the topographical maps of all European countries are adequate for the purpose of aerial navigation. One or two countries, notably Spain, are badly served, but apart from these few cases, the chief drawback to the existing maps is the number of different scales which have to be used. To give only a few examples, British Ordnance Survey Maps, on a scale of 1/253,440, compare with French maps on a scale of 1/200,000 and German maps on a scale of 1/300,000. The projections of these various maps are chosen to give the least distortion within the areas covered by the series, and, naturally, not with any view to their suitability for navigation. The air navigator, therefore, cannot have what, in spite of its antiquity, is still the most suitable form of projection for navigation—Mercator. He can, however, with suitable precautions, make good use of the material available, particularly over the short

distances which are the economic stages of present-day aeroplanes.

When the demand becomes greater, special aeronautical maps will be produced, not only to meet the needs of navigation, but to show the aviator the details of ground organization such as aerodromes, landing grounds, wireless stations, meteorological stations, prohibited areas, air corridors, air routes and danger areas, the equivalent of which is given to the marine navigator on the Admiralty charts. The International Commission for Air Navigation embodied in the International Convention a scheme for a uniform series of general and local aeronautical maps. A start was made on their production, and six general sheets have now been placed on sale by Great Britain; these are Britain, Balkans, Iraq, Egypt, Kordofan, and Oman. Owing, however, to the failure of other countries to produce their quota, further production was stopped, and it is unlikely that it will be resumed.

Considerable improvements in the design of aircraft compasses have been effected by the Admiralty Compass Observatory since the later days of the war. The aperiodic type of compass is now in almost universal use, and the various models fitted with this magnetic system are generally considered to be superior to any other existing type of magnetic compass. As the name implies, these compasses have no period, and very quickly settle after a turn, a property which is secured by a balancing of the frictional resistance of damping wires on the magnetic element against the magnetic moment of the element. They are also, to a larger extent than any other compass, free from northerly turning error, about which it may be necessary to explain that it is the error caused by the action of the earth's vertical magnetic force, introduced when the plane of the magnetic system of the compass is tilted out of the horizontal by the centrifugal force during a turn.

The most popular model for pilots' use, and the one

which is used on all large transport machines, and indeed, on practically all public transport aircraft, is the type 6/18 or its later modification the P.2. This has the "parallel grid" system of steering, that is, a series of parallel wires connected with a verge ring, which may be set against the lubber line to the desired course. In order to follow that course, it is only necessary so to steer the aircraft that the compass needle lies parallel to the grid wires. A smaller model of this compass, weighing only 2½ lb. has recently been produced, and found very satisfactory on light aeroplanes.

It is not possible to deal with the other models of compass which have been produced for various purposes, but only to say that aperiodic models of observers' compasses exist, suitable for use in conjunction with a radiogoniometer on board the machine, or for taking bearings of visible objects.

As with an aero engine, so with a compass, maintenance is the key to reliability. The compass cannot give good results unless it is accurately compensated and the residual deviations correctly determined at intervals. This process is called "swinging the compass," and for its performance, a compass base is an essential feature in the equipment of any good aerodrome.

Gyroscopic compasses have been developed to a state of high efficiency for use on ships, but their weight is high, and, while experiments are promising, no gyro compass is in sight which one could afford to carry on a commercial aircraft. The advantage of the gyro is that the disturbing forces are more easily controlled than in the case of the magnetic compass, where every piece of iron, with its own magnetic field, distorts the earth's magnetic field, whose true direction is our guide.

An attempt to get rid of the deviations caused by the magnetism of the aircraft has been made in America in another way, while still using the earth's magnetic field as the controlling force. The earth inductor compass depends on the phenomenon that an E.M.F. is generated in a coil

rotating in a magnetic field. The magnetic field is that of the earth. The coil is rotated on a vertical axis in such a position on the aircraft that it is outside the influence of disturbing magnetic elements. The changes in the E.M.F. induced in the coil as the course of the aircraft changes, are recorded on a dial in the pilot's cockpit in terms of degrees. It will be obvious that recording at a distance presents no difficulties, and that the compass itself may therefore be placed, if necessary, in the tail of the aeroplane. This instrument, though not yet fully perfected, has given good results.

In order to be independent of the magnetic field of the earth in the Arctic, where it was feared that the horizontal force would be too small to give stability to the compass, Amundsen arranged with the firm of Zeiss to produce a solar compass. This enables the pilot to steer by keeping an image of the sun on a ground glass screen; the instrument incorporates a clock which turns it to keep pace with the changing azimuth of the sun with time. Provision is made for adjustment to different latitudes. While, no doubt, development is still required, it is quite possible that the solar compass will become of value when air routes lie above the clouds.

One has devoted comparatively a large amount of space to the compass, for which there is good justification, since it is the basis of navigation.

The mariner's troubles would be halved by an absence of wind and current; the air navigator's troubles would equally be at least halved by an absence of wind. Wind has the effect of adding its velocity to that of the aeroplane. The resulting motion can be calculated by the triangle of velocities, if the two components are accurately known. The velocity of the aeroplane is given by the compass and the air speed indicator, subject to the correction of the compass for deviation and variation, and the correction of the air speed indicator for the lesser density of the air at an altitude. For the velocity of the wind, one may call in

the meteorologist to give a forecast, or the result of a pilot balloon observation, or one may proceed in the reverse direction and measure the motion of the aircraft over the ground by measuring the drift with a drift indicator, and the speed with a ground speed meter, or by timing between two landmarks. Whichever the method adopted, one has now the necessary data for calculating at any subsequent moment the position of the aircraft. This process is called dead reckoning, and the position so calculated is called the D.R. position. The value of dead reckoning is most realized when visibility becomes low, or a flight over the sea has to be undertaken. In other conditions it relieves the pilot or navigator of continued map reading, and simplifies the rapid fixing of position by the map at long and convenient intervals. It should be observed that the pilot flying the machine is not in a position to measure drift with a drift indicator, or carry out elaborate calculations. The pilot's usual method of determining drift is by what is called " the two point method," that is to say, he flies the machine so as to pass over two points on his desired track, and notes the compass course necessary to maintain this line. His ground speed is obtained by timing between two landmarks, and in his head he carries a mental dead reckoning.

However nebulous the rules may be, and in spite of the fact that they are applied subconsciously, this is the process which has been developed by every good cross-country pilot, and in all ordinary conditions it is sufficient.

Where the safety of passengers and the regularity of an air service are at stake, it is not sufficient to rely on these simple methods alone. Hence, on the continental air routes, an extensive system of aids to the pilot by means of direction finding wireless stations is being built up. This comes under the second heading of " fixing position."

It may be said at once that the elaborate system of astronomical navigation which has been laboriously developed at sea, through the era of the cross staff and the

astrolabe, to that of the modern sextant, is of very limited value in the air. The rare occurrence of a natural horizon has made it necessary to develop artificial horizon sextants, where the vertical is indicated by a bubble. One of the most successful of these is the R.A.E. sextant, developed in this country, but even with this, the accelerations of the aircraft acting on the bubble cause errors in the vertical, such that the position line obtained from a group of observations, may be 12-15 miles in error. Add to this that, with the most efficient mechanical aids to reducing the observations, the position line cannot be laid down on the chart in less than fifteen minutes, and the obvious fact that a special navigator is required to operate the process, and it is clear that this method cannot efficiently be used for any except long flights (say, 300 miles and upwards), where other means of fixing position are scarce, as for example, over the sea.

Over mapped country, as has been said, the simplest fix is the recognition of a landmark, preferably a town, railway, river or lake, these being the most prominent and readily recognizable of landmarks.

There is little to choose, however, between land and sea, when clouds or fog cover them both, and this is where the necessity comes in of developing the third and most modern method of fixing position—by wireless bearings. There are two main methods of using direction-finding wireless. One is to establish direction-finding stations on the ground and to take bearings of aircraft while they transmit, and then to re-transmit the bearings or positions by wireless telegraphy or telephony to the pilot of the aircraft. The other method is to place the radiogoniometer on the aircraft, and to take bearings of any ground W/T station which may be transmitting. A modification of the latter method is called the wing coil method; in this, no bearing is measured, but the aircraft is, by its means, enabled to steer towards the transmitting station, which must, therefore, be situated at the destination or on the route.

The method adopted up to the present on the continental air routes, is the first. It will be understood that, as in all methods of fixing position, except map reading, at least two bearings are required in order to obtain a fix. It follows, as a natural corollary of the fact that no navigators are normally carried on civil aircraft, and that the pilot, while flying the machine, is unable to make any but the simplest mental calculations, that positions are more frequently required than bearings. The pilot of an aircraft fitted with wireless, calls up the control station. Bearings are taken of his signal by the control station, and at least one other D.F. station. The subsidiary station passes its bearing to the control station, where the officer on watch plots the two bearings on a chart, determines the point of intersection, and passes a signal to the pilot of the aircraft, giving him his position in the following form: "Your position at 1423, 2½ miles S.W. of Tonbridge."

The chart used by the traffic control officer is a section of a Gnomonic chart, on which the great circle path of a wireless wave is represented by a straight line. This is shortly being supplanted by a specially prepared enlarged section of the International 1/1,000,000 map, which has the advantage of containing greater detail, while over the comparatively small area controlled by one ground station on the continental routes, the error of projection, for the purpose required, is negligible. The map is mounted on a board, special precautions being taken to counteract distortion due to shrinkage of the paper. A compass rose is inscribed round each of the D.F. stations, Croydon (control station), Pulham and Lympne, and in practice bearings are laid off by means of weighted cords fixed at the position of the D.F. stations. Experience in the operation of the D.F. stations at Croydon and Pulham during the last six years shows that positions given can generally be relied on within two miles.

The more rarely practised method of using D.F. bearings, that is, obtaining a bearing from one station only, is

generally operated by Croydon, for the purpose of giving pilots a course to fly to reach the aerodrome. Normally, when a pilot asks for a bearing, he is given the true bearing of his machine from the D.F. station, thus following established naval practice. In special cases, however, the reciprocal magnetic bearing is given, and in this case it is only necessary for pilots to apply deviation and drift to determine the compass course to steer to reach the aerodrome.

The wing coil method is now experimentally being introduced on commercial aircraft, but no general use has yet been made of it in civil aviation. The pilot orients his machine towards the transmitting station by balancing two signals in his telephones. He has then to maintain this course by the compass until the next period of transmission, when he again checks the bearing. It is a peculiar feature of this form of navigation that in any wind except a tail wind the final approach to the transmitting station is up wind. The track of the aircraft is a curved one, and special precautions have to be taken to counteract this.

The method of using a radiogoniometer on the aircraft is equally experimental, as far as the operation of regular air transport machines is concerned. The great advantage of it is the freedom it gives to the navigator to use any wireless station which may be transmitting and which is within receiving range, and to take bearings of those stations while maintaining the course of the aircraft. It clearly requires the services of a separate navigator to plot the bearings. Even if the pilot could operate the radiogoniometer himself, the bearings would be useless to him, since he could not plot them. The method is, therefore, limited to services on which he balance between the operational necessity and the economic possibility determines that the second member of the crew shall be a navigator.

The greatest difficulty in the operation of an air service is that created by fog. This is not so much a difficulty of navigation as of landing, but the subject is most appropriately

dealt with in this chapter. Flying above fog, in itself, presents no difficulty. Flying in fog or cloud, even if there were any necessity to do it, is possible, with the use of modern turn indicators. The reluctance to fly above fog is due to the pilot's fear of engine failure necessitating a forced landing with insufficient time to select a suitable landing place. The development of three-engined machines has now gone far to remove the danger of forced landings. Turn indicators, such as the Reid and the Schilovsky, by enabling the pilot to keep his machine on a level keel, ensure a true reading of the compass, and so make it possible to fly with safety to the comparatively comfortable strata above the fog or cloud. The wireless direction-finding organization enables the pilot to locate his position, and hence removes the difficulty of finding approximately his destination. There remains the problem of landing on the fog-bound aerodrome.

This problem has not yet been solved, but solutions are in sight. The most promising, and the only one which will be referred to, is the leader cable, which has given very satisfactory results on a model scale, and is about to be put to full scale trial. In essence, it consists of a long cable, laid just below the surface of the ground, having an alternating current passed through it. An alternating magnetic field is thereby created round the cable, and making use of the different directions of the lines of force in various positions round the cable, a special detector on the aircraft indicates to the pilot his position with reference to the cable, the direction of his craft's head with reference to it, and his height above it.

By laying the cable in a loop, with one part passing over the landing area, it is considered that pilots having been led to the vicinity of the aerodrome by wireless positions or bearings, will be able to follow the cable until, arriving over the landing area at a suitable height, they can throttle down and land. Should this or any other system of assisting the pilot to land in fog prove practicable, the greatest step

forward in the perfection of air transport in the whole of its history will have been taken.

It remains to consider the regulations concerning navigation.

The International Convention binds the parties thereto to impose uniform rules, a number of which refer to matters affecting navigation. The rules as to lights and signals, and rules for air traffic, are contained in Annex D of the convention and reproduced in Schedule IV of the Air Navigation (Consolidation) Order, 1923. The rules of the air and the navigation lights to be carried are, as far as can be, identical with those which have been developed by years of experience at sea. Their merit has been proved, and in very few particulars has it been found necessary to modify them in the light of the last six years experience.

The International Commission for Air Navigation has under consideration at the present time proposals for revised conditions for the carriage of navigators on board public transport aircraft, the effect of which will be to require pilots to obtain a 2nd class navigator's certificate when flying beyond certain distances overland, and certain shorter distances oversea, and at the same time to require the carriage of a separate 1st class navigator for flights of such duration as will require the carrying out of navigation operations which cannot be performed by the pilot flying the machine.

At the same time, revised conditions of examination for navigators are under discussion; these have already been put into force in Great Britain. The conditions of examination require a knowledge of astronomical navigation, and a high standard of attainment in meteorology for a 1st class navigator, while a 2nd class navigator is required only to know the principles of dead reckoning and radiogoniometry, with a lower standard of meteorological knowledge.

It is one of the original provisions of the International Convention that all pilots of public transport aircraft should pass a test in elementary air pilotage and meteorology.

This is carried out in the form of an oral examination, which is, of course, very much simpler than the examination for 2nd class navigators.

This system provides a natural ladder, which is built with an eye on the future. When the day of the big machine comes, the machine which flies 500 miles over the sea, it will carry a 1st class navigator-pilot-commander, with a second pilot, who may or may not be a 2nd class navigator, and probably also a mechanic; the machine which flies 300 miles overland will carry a 2nd class navigator-pilot, and those machines flying short distances only will be piloted by the junior pilots who have not yet obtained navigator's licences.

CHAPTER XII

NIGHT FLYING

NIGHT flying, as a subject, is largely an offshoot of navigation, inasmuch as the peculiar difficulties it introduces are, apart from the landing question, problems of navigation.

The subjects we have to deal with in this chapter are dealt with most naturally under the following headings—

1. Navigation.
2. Control.
3. Avoidance of collision.
4. Landing.

NAVIGATION

The principles of navigation laid down in Chapter XI apply equally to night flying. It is only here and there that methods have to be modified to suit the altered conditions. One cannot say that the conditions generally are less favourable, because, on clear starlight nights they are more favourable, while on dark nights, with low cloud, they are definitely more difficult. On foggy nights, as on foggy days, one must fly above the fog or not at all. The difficulty then introduced is chiefly one of landing.

On a clear night fewer landmarks are visible than by day, but one type of landmark sufficiently common in Europe, becomes a beacon, to wit—a town. Other landmarks usually visible are rivers, lakes, and coastline, the latter being clearly visible even on a dark night if surf is breaking. On a moonlight night many other features become clearly visible—woods being of particular note.

No one could attempt regular night navigation by any other method than a rigorous use of the compass. This involves the necessity of determining drift. Fortunately, on many nights, sufficient can be seen of the irregularities of the ground surface to enable a drift observation to be

taken, even when the objects used are not visible in the sense of being readily recognizable. Failing the direct drift observation, the drift can be obtained by taking the bearing of a light over which the machine has passed.

Given this ability to measure drift, one can proceed quite happily with landmarks only at considerable intervals. These may be natural, or they may be route lights specially provided for aircraft, or marine lighthouses. Taking the London-Paris route of 220 miles as an example, and including aerodrome location lights, six aerial lights have been installed on the English side of the Channel, and seven on the French side, while four French marine lighthouses have been specially modified for aviation; numerous other marine lights near the route are of great value to the aerial navigator.

Night lighting is still in an experimental stage, and while the experience of marine lighting engineers has been largely drawn on, certain new lines of development have been followed, with the result that the equipment is of considerably varying types. Space does not permit of a detailed description of all the different forms of lights. One must be content with a brief review.

In England, the route lights are situated at Tatsfield and Cranbrook, eight and twelve miles S.E. of Croydon and Tonbridge respectively. Both of these lights are of similar type, built by the Gas Accumulator Co. The illuminant is acetylene gas, and the light is controlled by a sun-valve so that it is automatically switched on at sunset and off at sunrise. The lights are entirely automatic in action, and are fed from cylinders, which need only to be renewed every six months. The lens is of the six-panel type, and is modified by the introduction of prismatic elements in front of it to distribute the light from the horizon to the zenith. The approximate candle-power in the beam is 53,000, the maximum intensity of the beam being directed at an angle of 2° above the horizontal, thence diminishing gradually towards the zenith. It is difficult to give any figure of

visibility to convey a definite meaning. The visibility of marine lights, as quoted in the Admiralty Light Lists, is the geographical range. This has very little meaning in the case of an air light, since the height of the aircraft varies. The figure of thirty-five miles quoted in the "Air Pilot" can, therefore, only be looked on as a general guide. Actually these lights have been observed at greater distances.

The character of these lights is still regarded as experimental. While Cranbrook exhibits a group flashing light of three white flashes every seven seconds, Tatsfield exhibits an alternating group flashing light of the same period with a succession of white, red, white flashes. This is expected, though not yet observed from the air, to be more distinctive than an all white light, on account of the flickering nature of many of the ordinary lights of the countryside, when observed from the air. The candle-power of the red light in the beam is naturally much less than that of the white, being only a matter of 29,000. The general structure of these route lights may be seen from the illustration on the opposite page.

After a high-power light to serve as a beacon, the navigator's next requirement is a location light for the aerodrome at his destination, equivalent roughly to the harbour light of the marine world.

At Croydon and Lympne aerodromes, the lights, consisting in each case of a number of 1,500 watt gas-filled incandescent lamps, are of 500,000 candle-power in the vertical beam, but only 23,000 in the horizontal beam, and have group flashing and group occulting characters respectively, while at Penshurst and Littlestone, the lights are of the automatic acetylene gas type, similar to the route lights, but of 13,500 candle-power; they have similar group flashing characters. The two former are only exhibited when aircraft are expected between sunset and sunrise; the two latter are automatically controlled and are in action from sunset to sunrise every night. An explanation

By courtesy of the *Gas Accumulator Co., Ltd.*

FIG. 4. CRANBROOK AIR ROUTE LIGHT

A general view of the 53,000 candle-power, automatically operated, acetylene gas-light erected at Cranbrook, Kent; a similar light is situated on Tatsfield Hill.

may reasonably be demanded why the Croydon and Lympne lights should have such high-power vertical beams. The answer is that the Croydon and Lympne lights were installed in the early days of civil aviation, and represent the first attempt to provide a fog penetrating beam. These lights are being superseded by Neon beacons.

At Croydon, a Neon beacon has been installed. This consists of sixteen glass Neon tubes, each 20 ft. long, arranged in the form of a vertical truncated cone, so that the appearance is that of a pillar of light. These Neon lights are similar to those, with which everyone is now familiar, used for advertisement purposes, but of course, modified in construction. This form of beacon has proved to have remarkable fog-penetrating qualities. It has, for example, been observed at a range of two to three miles by an observer stationed above a bank of fog some 300 ft. in depth. It is probable that this form of light will be adopted at other aerodromes.

In France, the lights established at the aerodromes and landing grounds of St. Inglevert, Berck, Abbeville, Poix, Beauvais, and Le Bourget (Paris), are of the Barbier, Bénard and Turenne type, with electric sources of light. These have candle-powers of 6,000 at St. Inglevert and Le Bourget, and 4,000 at the other landing grounds. The French have adopted the useful expedient of giving all their lights characteristics representing letters of the Morse code.

A useful modification has been made to the powerful marine light at Gris Nez by the superimposition of an air light, whose beam extends from the horizon to the zenith, thus enabling the actual light to be kept in view when an aircraft is so near the light as to be above the main beam. This auxiliary light varies in candle-power from 20,000 near the horizontal, to 2,000 near the zenith.

Many marine lights are masked on the landward side, but the French Government have removed the mask from the lights of Calais, Gris Nez, Dunkerque, and Touquet Point,

thus making them visible all round. Such powerful marine lghts have a great value to the air navigator, even though he be too high above the horizontal beam actually to see the light. The glare of the light and the beam itself is often visible for many miles.

France has established air lights at aerodromes in other parts of France, but the only one which merits special reference is that on Mont Afrique, near Dijon, at a height of 1,936 ft. above the sea. Here, a white flashing light, manufactured by Barbier, Bénard and Turenne, is operated on certain days of the month. This was originally designed to assist the return of bombing machines from Germany during the war. It has a candle-power of 1,000,000,000, and is stated to have a visibility of several hundred kilometres. The light source is provided by a powerful arc, and the lenses are of the Fresnel type.

Lights have been established on aerodromes in Holland, and the marine light at Scheveningen has been modified to show a light up to the zenith for aviation purposes. A chain of French lights was established on landing grounds between Belgrade and Bucharest for the operation of a night air mail service by the Société Franco-Roumaine, in 1923. During 1925, a night air mail service was operated between Berlin and Hamburg, and lights were established at various landing grounds en route. For the most part these were revolving incandescent electric lights, manufactured by the firm of Siemens-Schuckert. Nine of these were used. There were also two gas accumulator acetylene lights established on two of the landing grounds. At the terminal aerodrome at Staaken (Berlin), a Neon beacon was found very satisfactory, but at Hamburg a multiple fixed light, consisting of a number of incandescent lamps designed by the Pintsch firm, was found costly and unsatisfactory.

The most extensive organization of an air route for night flying has been carried out in the United States, where the lighting of practically 2,000 miles of route from New York via Chicago to Rock Springs, Wyoming, is almost complete.

The general scheme, though not yet carried out in all sections, is as follows—

The main aerodromes are illuminated by floodlights and the boundaries marked by flashing red lights, while the direction of the wind is indicated by red lights sunk flush with the aerodrome surface. At each of the main aerodromes a 36 in. Sperry arc revolving beacon is established. It is estimated that these lights, of 500,000,000 candle-power, are visible in suitable conditions over a distance of 150 miles. At the emergency landing grounds, approximately twenty-five miles apart, are installed 18 in. beacons of 5,000,000 candle-power, with an incandescent source of light. These also have a flashing character, and their visibility is estimated at forty miles. In addition, at intervals of three miles, are placed small automatically operated and controlled acetylene gas beacons of 5,000 candle-power, visible at a distance of seven miles.

Experience alone will show whether such an elaborate system of lighting is necessary. In principle, the route light is required only as an occasional check on the course, not as a general guide. In normal conditions, less than half these lights would ensure that no ordinary navigator would ever lose sight of them. In fog, it is possible that none of them would be seen at all.

Particulars of the air lights of Great Britain are given in the "Air Pilot," and of certain foreign countries, notably France and Holland, in the supplements thereto. In time, this publication will extend to cover all countries of interest to British pilots.

Before leaving the subject of lights as applied to navigation, it is necessary to mention the lighting of high obstructions on the routes. The most obvious and most dangerous, because the least visible, of these obstructions, are the high W/T masts, which are now becoming so common all over the country. To mention the highest of these, Rugby, which has twelve masts 820 ft. high, is sufficient to show the danger. Considerable experiment has been carried out in

this country to determine the best method of lighting these obstructions. Most of the masts are marked by ordinary red incandescent electric lamps, but a recent installation at Horsea, near Portsmouth, consists of a small, automatic, gas operated, flashing light at the top of the mast, with a Neon light beacon on the ground at the base. It is not necessary to remind the reader that the top of such high masts, in this country, may frequently be in the clouds, while mist below would obscure all normal lights.

Having dealt with the types of lights which have been established as substitutes for the visible landmarks of the day, one may return to the general problem of navigation. Where the clouds are moderately high, allowing of safe flight beneath them and a view of the ground, it is clear that the ordinary methods of navigation by dead reckoning suffice. It seems axiomatic, however, bearing in mind that clouds with no moon are almost invisible at night, that when the clouds are so low as to approach the tops of the hills, the only safe place to fly is over the top of the clouds. It is not suggested that all danger has been removed when the aeroplane gets above the clouds. The pilot still has the worry of a possible forced landing, but with three-engined machines this has been largely removed, and at least it is indisputable that, from all other points of view, he is infinitely better off. Until this method can be adopted, no regular night flying will be possible.

Above the clouds an auxiliary method of fixing position is required. Without it, the drift cannot be ascertained. Radiogoniometry, on short routes, is the only solution. The organization required is the same as that by day, and is more fully discussed in other chapters. The only point of importance to mention in connection with night flying is the existence of night errors in the bearings. This has not yet been fully explained, nor is it clear, at present, that the same errors which affect a ground direction-finding station, will affect a direction finder, say, of the wing coil type in the machine. This is one of the points on which it is hoped to

obtain information in the near future. It is fairly safe to say, however, that the navigator can look for such assistance from radiogoniometry as will enable him to bring his craft within such a radius of his destination, that it will be possible to locate the aerodrome by one of the auxiliary methods discussed under " landing."

One final point—when it comes to navigation by night over long routes, the navigator using a sextant above the clouds has all the stars to choose from, and is not limited to one astronomical position line as he is by day.

CONTROL

Flying in certain conditions at night introduces problems of control similar to those experienced in cloud and fog by day. Due to the lack of a visible horizon, the pilot only maintains the level of his machine with difficulty, and there is danger of a bank inducing a turning movement, which may develop into a spin. To counteract this, it is essential that night flying machines should be fitted with efficient turn indicators. The Reid and Schilovsky types have both been found satisfactory, and both give an indication of a turn by means of coloured electric lights, which attract the pilot's attention. It should be realized that the compass does not indicate the rate, or even, in some cases, the fact of a turn, due to the disturbing influence of the earth's vertical force when the compass card is not horizontal.

Recent developments in the perfection of automatic controls for aeroplanes indicate the future line of progress, at least, for all large machines. The gyro rudder control, designed by the Royal Aircraft Establishment, has given very satisfactory results on test, but is still subject to certain mechanical defects which will be eliminated by experience. Already it is possible to leave the aeroplane entirely to the gyro rudder control for long periods with no action on the part of the pilot. To change course it is merely necessary to reset a lever.

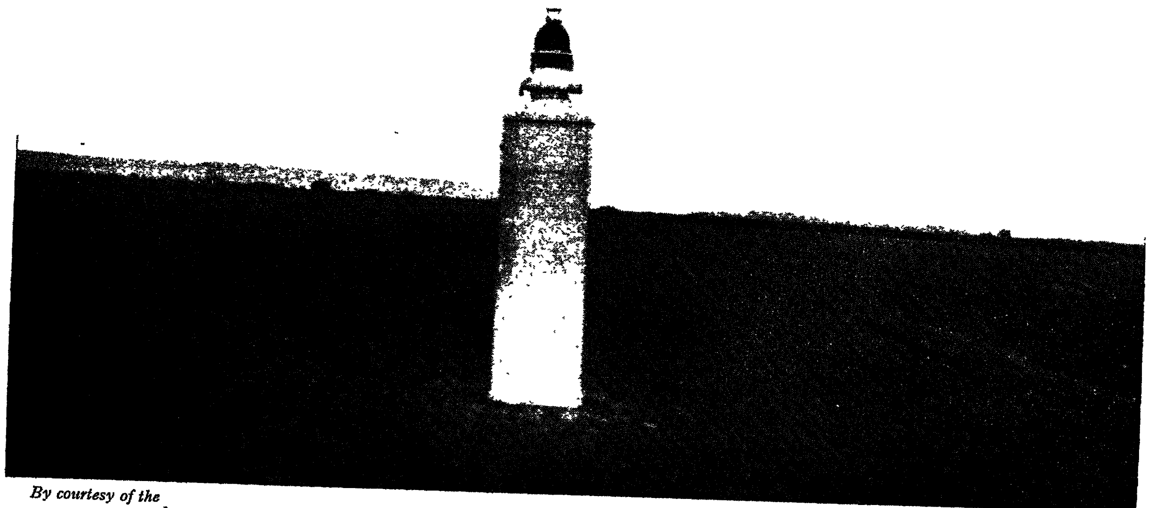
The development of automatic controls for aileron and elevator is proceeding. These instruments are heavy, and it will be some time before it will be economically possible to fit them on any but large machines, but the day is not far distant when the troubles of control in bad visibility will no longer exist, and turn indicators may be dispensed with.

One point essential to the control of an aeroplane at night is adequate illumination for the instruments without dazzling the pilot. Luminous instruments are most satisfactory for this purpose, but where general illumination of the cockpit is required, red light has been found most satisfactory.

AVOIDANCE OF COLLISION

This subject has been dealt with, generally, in Chapter X, and it is only necessary to refer here to its special aspect at night. The problem is to render the aircraft visible in such a way that its type may be identified, and that its direction of motion may be immediately obvious to the pilot of any other aircraft near. Fortunately, in this, aviation had the advantage of drawing on long years of experience in marine navigation, the results of which are now embodied in "The Regulations for Preventing Collisions at Sea." It was only necessary to modify the marine navigation lights in minor details to suit the altered conditions of the air; the result is embodied in the International Convention, Annex D. On such a point as this it would be fatal if any State of importance were to depart from the international system, and, as a fact, all States which have promulgated air regulations have adopted the rules of the International Convention on this matter, whether or not they are parties to the convention. There are probably one or two minor points on which it will be found expedient to amend the rules of the convention, but taken as a whole, experience has shown the rules, which are in effect the marine rules, to be well suited to the conditions of air navigation.

For the benefit of the uninitiated, it may be said that an



By courtesy of the Gas Accumulator Co., Ltd

FIG. 5. A BOUNDARY MARKING LIGHT

One of the gas-operated flashing lights used for the marking of the boundaries of civil aerodromes in Great Britain.

aeroplane carries four navigation lights—white head and tail lights, red port and green starboard lights. The lights are so arranged that the head light and both side lights are visible from dead ahead ; the head light and green light are visible from dead ahead through an angle of 110° on the starboard side ; the head light and red port light through a similar angle on the port side ; the tail light alone is visible through the remaining arc. As an example, then, a pilot who sees red and white lights on his starboard bow, knows that an aeroplane is crossing his bows in such a way that collision is possible, and, by the rules of the air, that he must give way.

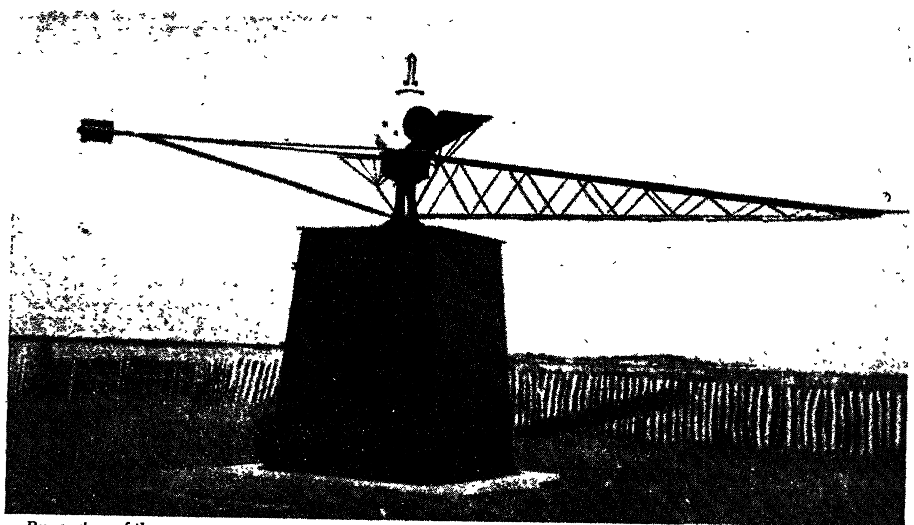
Airships carry all lights doubled, a free balloon a single white light, while a fixed balloon must have the whole length of the cable marked by groups of red and white lights.

One of the difficulties in the application of these rules is, without increasing the weight unduly, to provide adequate screening to restrict the lights to their proper sectors, on the successful attainment of which their correct interpretation depends. There is still room for improvement in this respect.

LANDING

Light is again harnessed for the benefit of the pilot in the solution of this problem. Having located his aerodrome, the pilot requires, first, an indication of the boundaries of the landing area ; secondly, the marking of obstructions round the aerodrome ; and, thirdly, an indication of the direction of the wind.

In the past, various indirect methods of satisfying the first requirements have been adopted, but on the State controlled civil aerodromes of Croydon, Lympne, Penshurst, and Littlestone, the policy of outlining the whole of the boundary by red flashing lights has been adopted as the most satisfactory after some years experience. The lights are spaced at intervals of 150-250 yards as required, and each consists of an automatic gas-operated light, flashing once a



By courtesy of the *Gas Accumulator Co., Ltd.*

FIG. 6. AN AUTOMATIC WIND INDICATOR

A gas-operated automatic, illuminated, wind indicator at Littlestone landing ground, Kent ; a similar indicator is installed at Penshurst.

second, and continuing in operation night and day without attention for six months. These lights, as in fact all air lights, are visible from all directions from the horizon to the zenith.

The highest points of all important obstructions round aerodromes are lit by fixed red lights, either incandescent, electric lamps, or oil lamps, as convenient.

To indicate the direction of the wind at Croydon, a system of sunken electric lamps has been installed, in accordance with the provisions of Annex D of the convention (the only aerodrome in the world equipped with this system). Provision is made to indicate eight different wind directions, controlled by a switch in the control tower. While the system functions quite satisfactorily, it is not one which is suited to small aerodromes, or aerodromes with restricted landing dimensions in certain directions. Moreover, it is costly to install. The convention will probably be amended to permit of a simpler, less costly, and universally applicable system.

The most successful aid to night landing has been found to be the flood lighting of the whole of the landing area. The flood light is placed on the windward side of the aerodrome, and the pilot lands over, but to one side of the light (to avoid the shadow of his machine). The Croydon floodlight consists of a carbon arc lamp situated at the centre of a compound lens system, which covers 180° in azimuth, but restricts the main beam to a narrow horizontal plane, which, however, may be tilted up or down as required. This light has also been modified to be used when required as a rotating beacon, the plane of the main beam being then tilted up to about 45° above the horizontal.

Recent experimental observations of Neon and other lights suggest that it will be necessary for landing on a misty or foggy night to use a system of Neon tubes sunk under glass plates on the aerodrome, to indicate the landing area and the direction for landing when flood light and boundary lights are obscured. Neon lights are visible as a

pool of light on top of a bank of fog, which obscures all other lights, while from an altitude above the fog bank the lights themselves may sometimes be seen.

At unattended landing grounds (Penshurst and Littlestone), the direction of the wind is indicated by an automatic " T " painted white and illuminated by an occulting, gas-operated light, of 27,000 candle-power. (See page 92.)

One cannot, of course, close a chapter of this kind without reference to the petrol flare, which was used with so much success during and since the war. Petrol flares have very good mist penetrating qualities, and it is probable that the requirements for many aerodromes would be adequately met by their use.

The illumination of aerodromes by single searchlights, or batteries of searchlights, has been extensively experimented with on the continent. In America, on the trans-continental air mail route, a flood light system, similar to that at Croydon, has definitely been adopted.

The pilot also requires some form of emergency lighting in case of a forced landing. The three forms of light which have been used up to the present are: (*a*) pyrotechnic flares, attached to the wing tips and ignited by the pilot by the closing of an electric circuit; (*b*) pyrotechnic flares, attached to a parachute ignited electrically at the moment of release; (*c*) electric projectors, attached to the bottom of the fuselage, illuminating the ground below and ahead of the machine.

Of these, the first are in common use in this country, and the only serious objection to them, apart from the fact that they cannot be used more than once, is the reflected glare on the propellor of a tractor machine, with the propellor in front of the pilot. Screening devices are being introduced. The third type, manufactured by the Goerz Co., were found very satisfactory in Germany in the night flying experiments of 1925. The general opinion in this country, however, is that they do not give as satisfactory a degree of general illumination as does the Holt wing tip flare.

It does not appear probable that any radical departures from the present system of lighting air routes in this country will be made for some time, except in connection with the problem of landing in fog. In this connection, it is possible that the use of the leader cable, in conjunction with a system of Neon lights on the landing ground, may prove the eventual solution.

CHAPTER XIII

LICENCES

THE general conditions for the issue of licences to the operating crew of aircraft, and for the licensing of aircraft, are laid down in the International Convention, and amplified, in the case of Great Britain, in the Air Navigation (Consolidation) Order, 1923 (usually referred to as the Air Navigation Order), and in the Air Navigation Directions. In addition, in Great Britain, provision is made for the licensing of aerodromes used for public transport.

PERSONNEL

Conditions are laid down in Annex E of the International Convention for the issue of certificates to the following categories of personnel—

For Flying Machines (Heavier than air)

1. Private pilot's flying certificate (the " A " licence).
2. Pilot's flying certificate for public transport aircraft (the " B " licence).

For Lighter-than-Air Craft.

1. Balloon pilot's certificate.
2. Airship pilot's certificate (1st, 2nd, and 3rd class).

For all Types of Aircraft

Navigator's certificate.

The detailed provisions whereby this is made effective in Great Britain are contained in the Air Navigation Directions (A.N.D.3). In addition, Schedule II of the Air Navigation Order empowers the Secretary of State for Air to issue licences to competent persons for the inspection of aircraft as required by the International Convention.

Detailed provision for the issue of these licences, which are called " ground engineers' licences," are contained also in A.N.D.3.

The convention requires that all flying personnel shall be medically examined and found to comply with certain standards of fitness as a condition of being licensed to operate. These conditions are laid down in A.N.D.3.D. Pilots of private aeroplanes are allowed to have this examination carried out by a private medical practitioner, but all others are required to attend before the Royal Air Force Medical Board once every six months.

The medical examination is directed solely to the discovery of defects which may lead to failure in the performance of duties in the air. Pilots and navigators of public transport aircraft are not allowed to enter on their duties before the age of nineteen or after the age of forty-five. Among other things they must possess visual acuity equal to 100 per cent for each eye without glasses. Special attention is paid to nerve, lung and heart troubles, and the applicant must have no defect which might interfere with the satisfactory and safe performance of his duties at any altitude, even during prolonged and difficult flight.

The practical and theoretical tests for an " A " licence are limited to a test of flying capacity, including a flight to 6,500 ft., landing without engine, figure of eight turns, and landing within a specified area, and an oral examination in the rules of the air, lights and signals, etc. In practice, the examination is often carried out by the local aero clubs, and the certificate of the Royal Aero Club is accepted as proof of competency. The licence is limited to the types of aircraft which the candidate has proved himself capable of flying, and for this purpose, flights in the vicinity of an aerodrome, regarded as instructional flights, are permitted without a licence.

A candidate for a " B " licence is required to produce proof of having carried out thirty-five hours solo flying, and in addition to the practical tests for a private pilot's

certificate, he is required to carry out a cross-country flight of 200 miles and at least half an hour's night flying. The technical examination is carried out orally by the Air Ministry, and includes the theory of flight, control of an aeroplane and rigging; a general knowledge of aero engines, their use, repair and maintenance; a knowledge of the instruments used in flying machines; elementary navigation and meteorology, and a sound knowledge of the rules of the air, lights and signals, etc. The licence is limited to those types of machines which the candidate has proved himself capable of flying. In practice, the Air Ministry accepts the certificate of competent observers, who have witnessed flight tests by the candidate, for this purpose.

In general, the principle governing the administration of these provisions is that a private pilot must be sufficiently competent to avoid becoming a danger to the public, both in the air and on the ground, while a much higher standard is demanded of the public transport pilot, who is, in addition, responsible for the safety of the passengers and freight he carries.

There are at present in existence 113 "A" licences and 83 "B" licences.

Eight balloon pilot's licences are at present in existence, though there are other balloon pilots who obtained certificates from the Royal Aero Club before the war.

The conditions for the issue of a licence include five balloon ascents, of which two must be solo ascents, one by day and one by night. The technical examination is similar to that for a "B" licence, except that aerostatics and the construction of balloons and their control are substituted for the corresponding sections on aeroplanes and engines.

The conditions for the issue of airship pilot's licences are somewhat more complicated. The three classes of licence qualify the holders to command ships of less than 200,000 cub. ft. capacity, from 200,000 to 700,000, and over

700,000 respectively. Periods of service in certain capacities on board airships are required as qualifying periods for the two higher categories of licence, in addition to a number of flights and landings carried out by the candidate on the type of ship for which he desires a licence. The technical examination is graduated for the three classes, and includes those subjects which are the common ground of all aviators, and special subjects peculiar to airships, such as the physical and chemical properties of gases and materials used in airship construction, aerostatics and aerodynamics, airship control and handling, etc.

There are at present two 1st class airship officers and two 2nd class.

The licensing of the navigator has, to some extent, been dealt with in Chapter XI on Air Navigation. The same conditions apply to the navigators of all types of craft. Both the 1st and 2nd class examination are limited to written papers and practical and oral tests on the ground. In lieu of practical tests in the air, long periods of air experience are called for. The 2nd class navigator is required to produce proof of having had two years' air experience, during which at least 300 hours must have been spent in the air as an operative member of the crew; similarly, the 1st class navigator is required to have had at least four years' air experience and 600 hours in the air, of which at least 100 hours must have been as a navigator and fifteen hours at night.

The revised conditions for the carriage of navigators will probably come into force, in part, on the 1st January, 1927, and in part twelve months later. In the meantime, no services are at present being operated which require the carriage of a navigator. The new conditions will probably have the effect of requiring pilots of public transport aircraft flying more than 25 Km. over the sea, or more than 160 Km. overland, to be qualified as 2nd class navigators, while a separate 2nd class navigator will be required for the majority of night flights; 1st class navigators will only be

required on heavier-than-air craft, when flying more than 500 Km. over the sea or over unmapped country, and on all airships of the largest category. There are at present two 1st class navigators and four 2nd class.

Fees are collected by the Air Ministry for medical examinations, technical and practical examinations, and for the issue and renewal of all licences. The fees chargeable are set out in Schedule VI of the Air Navigation Order.

AERODROMES

The licensing of aerodromes is, by comparison, a simple matter. The sole principle involved is that operating companies who undertake to carry passengers for hire or reward shall not do so from places which are definitely unsafe for the purpose. This is regarded as a domestic matter, and no provision is made for any regulation of this description in the International Convention.

The convention calls upon each contracting State to notify to the other States particulars of aerodromes at which aircraft engaged in international air traffic are compelled to land for customs or other purposes. In pursuance of this provision, Great Britain has nominated the London Terminal Aerodrome at Croydon, and Lympne, in Kent, as customs aerodromes for landplanes, and Southampton (Woolston) for seaplanes. At these places, the necessary customs and aliens' inspection facilities are provided. No aircraft coming from abroad is allowed to land at any other place before having landed at one of these.

The convention further provides that every aerodrome in a contracting State, which, on payment of charges, is open to public use by its national aircraft, shall also be open to the aircraft of all the other contracting States. Similar provision is made in all agreements between this country and non-contracting States.

In the Air Navigation Order and A.N.D.3., provision is made for the licensing of aerodromes, and it is laid down that no place shall be used as a regular place of departure or

landing by *aircraft carrying passengers for hire or reward*, unless it is so licensed. All aerodromes so licensed for public use are open, on payment of charges, to the use of the aircraft of all contracting States.

It is an important point to notice that this provision in no way affects the flying of a private aircraft, even if carrying a non-paying passenger, from any place the pilot desires, subject to the ordinary laws of trespass.

Aerodromes are licensed on application to the Civil Aviation Department of the Air Ministry, either for all types of aircraft or for certain specified types. There are a matter of half a dozen aerodromes in this country licensed for all types of aircraft. These are mostly connected with aircraft manufacturers' works and are, consequently, in a measure permanent. By far the largest number of licences, however, are issued for aerodromes restricted to certain types of aircraft, and usually only required for periods of a few days or weeks for the purpose of joy-riding. Much of this work is done with the Avro type of machine, and a normal size for such an aerodrome is about 300 yd. square. The ground is inspected by a representative of the Air Ministry, or, in some cases, where the pilot is well known to be reliable, by the pilot himself. A licence is issued on a report, accompanied by a 6 in. Ordnance Survey map, showing that the surface is suitable, and that there are sufficient clear runs, with no dangerous obstacles, of adequate length to give a safe " take off," and on production of proof that the prospective licensee has made arrangements with the owner of the ground.

Particulars of all licensed aerodromes, with the exception of these temporary aerodromes, are contained in the " Air Pilot," as are also particulars of all Royal Air Force aerodromes, which are open to civil aircraft in emergency. In this country there is only one other class of aerodrome—private unlicensed aerodromes (in most cases the property of aircraft manufacturers), which are in some cases available for use in emergency or by permission of the owners.

AIRCRAFT

The International Convention requires that every aircraft engaged in international navigation shall be registered and shall carry its nationality and registration marks, and that it shall also be provided with a certificate of airworthiness. The Air Navigation Order and Directions apply these conditions in Great Britain to all civil aircraft.

Details of the registration and marking of aircraft appear in Annex A of the convention and in Schedule I of the Air Navigation Order, and details of the conditions for issue of certificates of airworthiness appear in outline in Annex B of the convention, Schedule II of the Air Navigation Order, and in A.N.D.3.

An aircraft may be registered without being certified airworthy. It can only be registered in the country in which it is owned, judged by the nationality of its owners. For this, and all other purposes of administration of the Air Navigation Act, Great Britain and Northern Ireland are indivisible, and the administrative work is carried out by the Air Ministry.

On registration, a certificate is issued to the owner of the aircraft and a registration mark consisting of four letters assigned. This, together with the nationality letter, is painted in large letters on the top and bottom planes and on each side of the fuselage, the nationality mark being further painted on the rudder and elevator. The nationality mark for the British Empire is G. The first letter of the registration mark indicates the country of the British Empire, e.g. E = Great Britain, C = Canada. A specimen marking of an aeroplane registered in Great Britain is, therefore, as follows : G-EASY.

The procedure for obtaining a certificate of airworthiness commences with the design of the aircraft. A type certificate must be obtained for each new design. To administer this section of the regulations, an airworthiness department has been set up under the Directorate of Aeronautical Inspection at the Air Ministry, with headquarters at the

Royal Aircraft Establishment at Farnborough. This department checks the stress calculations and all details affecting the safety of the aircraft, from drawings and particulars supplied by the designer. At any stage, strength tests of particular parts may be called for. Throughout construction, a rigid system of inspection of all component parts is enforced, partly through the medium of the firm's own inspectors and partly by the inspectors of the aeronautical inspection department. The enforcement of this system engenders a sense of responsibility in all individuals, for it enables the author of bad workmanship to be traced.

On the completion of the aircraft, it is submitted to contractor's flying trials ; then, after any necessary modifiactions, to official flying trials. If these are satisfactory, a type certificate of airworthiness is issued. A sliding scale of fees for the issue of " C. of A.'s," depending on tare weight of the aircraft, is laid down in Schedule VI of the Air Navigation Order.

For all subsequent aircraft of the same type, inspection is carried out by the constructor's staff of inspectors, who are required to proceed on lines laid down by the Air Ministry. On the receipt of an application, provided the Air Ministry is satisfied that the aircraft conforms to the type for which a certificate of airworthiness has previously been issued, and that the inspection arrangements have been adequate, a certificate of airworthiness is issued for any subsequent aircraft.

In order to ensure that all aircraft are maintained in an airworthy condition, it is further laid down that periodical inspection of aircraft may be carried out by representatives of the Air Ministry. All aircraft are thoroughly inspected after any major repairs have been carried out. In addition to this, a daily inspection of all aircraft used for public transport is carried out by licensed ground engineers, in accordance with the provisions of Schedule II of the Order.

No daily inspection of private aircraft is required, and in

fact, many of the conditions for the granting of certificates of airworthiness for private aircraft are in process of being modified.

These are the only licences in the strict sense of the term with which we are concerned in civil aviation. Under this chapter, however, may be mentioned certain permits which are necessary for the carrying out of particular operations.

1. Except with the special permission, in writing, of the Secretary of State for Air, no photograph of a prohibited area may be taken from an aircraft. (Air Navigation Order, Art. 11.)

2. No articles may be dropped from aircraft except in accordance with directions issued by the Secretary of State. (Air Navigation Order, Art. 13.) This is intended for the authorizing of mail bag dropping.

The definite distinction between 1 and 2 will be noticed. Before mails can be dropped from an aeroplane, an air navigation direction is required to authorize it.

Wireless operators' licences are issued by the Postmaster-General.

CHAPTER XIV

PASSENGERS, FREIGHT, AND MAILS

It is hardly necessary to remark that the organization for the handling of both passengers and goods in an air transport service is of a more intimate nature than that of either a railway or shipping line. The passenger arrangements, in fact, bear a strong resemblance to those of the old friendly days of the stage coach. If it were not that the Air Ministry regulations now forbid a passenger to ride in the equivalent of the coveted box seat next to the driver, the parallel would be still more complete. The arrangements for the collection and delivery of goods partake rather of the nature of those of a road transport organization.

To what extent this is a consequence of the relatively small volume of traffic, and to what extent it will disappear with the growth of the industry, is a question to which the future holds the answer. Since air transport never will supplant surface systems of transport, it may well be that this intimacy, this close personal attention to the individual or to his goods, will prove to be one of the keystones to success—perhaps the principal element which, with speed, will permanently attract a quota of the traffic from the older systems.

PASSENGERS

To get an idea of how the passenger fares, let us assume that a business man wishes to travel from London to Paris. He books his passage at any travel agency or direct from Imperial Airways, Ltd. He has a choice of several machines during the day. For example, he may leave about 8 o'clock in the morning and arrive in Paris in time for lunch. The majority of passengers, however, prefer a more leisurely departure, and assuming that to be so in this case, the passenger delivers himself and his baggage at the Hotel

Victoria, in Northumberland Avenue, shortly before 10.45 a.m. A party of air travellers waiting at this modern hotel for the car to Croydon aerodrome, may not closely resemble a party of their ancestors waiting at "The George," Southwark, for the stage coach to Brighton, but there is an unmistakable similarity in the system.

Having arrived at the hotel, the passenger's troubles are ended. From this point he need have no initiative to find himself at a similar hotel in Paris about three o'clock that afternoon. He is met at the Hotel Victoria by a representative of Imperial Airways and a luxurious limousine. His luggage is handled for him and he arrives with it at Croydon aerodrome between 11.30 and 11.45. The machine leaves at 12.0 noon. He will see it standing on the "tarmac" when he arrives, and will hear its engines run up while he is going through the few formalities from which no traveller can escape.

He is first taken to the offices of the company, where both he and his baggage are weighed. The former is a precaution to ensure better loading of the machine, the latter is for the usual purpose of charging for excess weight. Each passenger is allowed to carry 30 lb. of luggage free, and for the journey to Paris pays at the rate of 4d. per lb. on excess.

If he wishes, he may insure himself by purchasing an insurance coupon at the extremely low rate of 1s. per cent. Some idea of the quality of the "risk" may be gathered from the fact that the insurance companies (British Aviation Insurance Group) allow the transport companies to issue coupons up to a value of £2,000 in any one case without reference. While this is going on, his passport is collected, and, if he is not a British subject, he is asked to fill in an embarkation card. These are taken by the company to the Aliens Inspection Officer, while his luggage is taken to the customs house. It only remains for him to attend at the inspection of his baggage, and to receive his passport from the Aliens Officer, who by this time has satisfied himself of its adequacy. Both insurance coupons

and aliens cards are issued to passengers, if desired, by the travel agencies when tickets are issued. The card can then be filled up before arrival at Croydon.

Still escorted by one of the company's traffic officers, he emerges on to the aerodrome and is given his seat in the machine, now standing with its engines " ticking over " and with guards round the propellors. His luggage is brought from the customs house by the aerodrome traffic hands, and stowed away (except for those items " wanted on the voyage ") in the special luggage compartment of the machine. The door of the cabin is secured, and our passenger with his ten or more fellow travellers finds himself, with no more ado, en route for Paris.

The interest of a journey by air is greatly increased by the study of a map. While a pictorial map is fixed in the cabin of most of the machines of Imperial Airways, the passenger who takes with him a good topographic map ensures for himself a joyful passage. Instruments in the cabin tell him the altitude and the speed of the machine, and he, in truth, settles down to study geography in an arm chair.

On arrival at Le Bourget, the reverse process is carried out, and the passenger is deposited in a car, with his baggage, at the Hotel Edward VII, in the Avenue de l'Opéra. Hotels are used as the meeting places for passengers in most of the cities served; in Brussels—the Palace; in Cologne—the Dom; in Zurich—the Victoria. As an exception, in Amsterdam, passengers are collected at the offices of the Royal Dutch Air Service in the Leidsche Plein.

Reverting for a moment to the question of insurance and risk, it is of interest to note the figures given in Table A, on page 108. It will be seen that in the worst year (1924), there was only one fatal accident to a British transport machine for a flying mileage of 936,000, or one passenger killed for over 130,000 miles flown. In 1925, 862,000 miles of flying produced no accidents on British air lines resulting in injury to passengers.

TABLE A

Paying Passengers Killed or Injured on Recognized British Air Transport Services

	May, 1919 to Dec. 1919	1920	1921	1922	1923	1924	1925
Fatal accidents .	1	1	nil	nil	1	1	nil
Passengers killed .	1	2	nil	nil	3	7	nil
Passengers injured .	2	2	nil	1	nil	nil	nil
Mileage flown . .	104,000	644,000	225,000	717,000	943.000	936,000	862,000

FREIGHT

It has been said that the freight traffic partakes rather of the nature of an express service. It is, in fact, a super-express service. Not least among the contributing causes to the speed attained, is the reduction in the number of trans-shipments required, and the expedition of customs clearance.

The arrangements for the collection and delivery of goods are quite simple. Let us illustrate, for example, the departure and arrival at Croydon aerodrome. Imperial Airways carry out a great deal of their business through the agency of Lep Transport & Depository, Ltd., who maintain a large staff of clearance clerks in their office and depot at Croydon.

These agents collect goods from commercial houses and the principal London railway stations, as and when required, and convey them to Croydon every morning in time for the services for which they are destined. In addition to this, Imperial Airways make a daily collection from other agents and from the large stores who are regular users of air transport, and who do not ship through an agency. This collection is made in the morning in time for all the goods to leave Croydon on the same day. There is no reason therefore why goods should normally be in transit for more than one day, a point which is of considerable importance with some classes of goods.

Arrived at Croydon, the goods pass straight through customs and are loaded on to the waiting machines for Paris and Zurich, Brussels and Cologne, and thence by German lines to Central Europe, and to Amsterdam, and thence by Swedish and German lines to Scandinavia and North Germany. Small quantities of goods and delicate articles are loaded in the luggage compartments of passenger machines, but goods generally are now taken in special machines, which may be reserved for that purpose, or may be temporarily converted passenger machines. The general tendency is to carry goods on such single-engined

aircraft as remain on the company's active fleet, and to reserve the newer three-engine types of machines for the carriage of passengers.

On arrival at the destination, according to the time of day, the goods are either passed straight through customs and loaded on to the delivery vans for distribution, or remain in bond until the next morning.

Goods arriving at Croydon aerodrome are passed on to Lep Transport & Depository, Ltd., with consignment notes and all necessary customs papers for clearance and delivery in London and the provinces. The red "Lep Transport" motors can be seen leaving Croydon aerodrome three times a day, filled up with goods for delivery; these motors are loaded within one hour after the aeroplane arrives, which means that the necessary customs papers have been passed, and the packages inspected by the customs. In the event of very important packages having to leave Croydon urgently, they can do so within five minutes of the aeroplane arriving. A special motor is sent to London at once to deliver them.

Generally speaking, freight collected from consignors in the morning in, say, London, arrives in Paris too late for delivery during business hours, after allowing the necessary time for clearance of the manifests. When, however, delivery is specially required, the company make arrangements for the special clearance of the goods, and they are then, assuming them to be small and valuable, placed on the passenger car from the aerodrome, and delivered by the driver immediately after the disposal of the passengers. For this, a special fee is charged. Many classes of goods are well able to bear this charge, which, in the case of valuable articles such as jewellery, is more than saved by the reduction of insurance rates, and, in the case of delicate articles, is again saved by the minimizing of risk of damage.

In this particular feature lies the peculiar advantage of the transport of goods by air. The much smaller amount of handling involved in air transport and the isolated

position of the freight during most of the period of transit, result, first, in a reduction of the risk of loss by pilferage, and, second, in a reduction of the risk of damage. Both of these very important factors are of vital importance with certain types of freight, and both result in the lowering of insurance rates to a level below that obtaining in surface transport.

The following comparative table of surface and air rates to a number of places sufficiently illustrates the advantage—

FREIGHT INSURANCE PREMIUMS PER £100

	Surface transport.		Air transport	
	s.	d.	s	d
London to Paris . .	6	8	2	-
,, ,, Amsterdam .	6	8	3	-
,, ,, Cologne . .	7	6	4	-
,, ,, Zurich . .	7	6	5	-

These factors have led to a considerable demand for air transport of gold and other precious metals, precious stones and jewellery, dresses, millinery and furs, paper money and securities. During the year 1925, for example, Imperial Airways carried bullion to the value of over £10,000,000.

These are by no means the only classes of goods which it has been found beneficial to send by air. They include samples of all kinds, and range from live stock and motor-bicycles, to perfume and such other delicate articles. An obvious advantage of air transport is that goods can be practically handed from the representative of a trader in London to his representative in, say, Paris, with only one intermediary, and that the aircraft itself. Thus, a manufacturer in London who has received a telegraphic request from his agent in Paris to send him particular samples could, during the morning, send his own representative to Croydon aerodrome, where the goods would be handed over to Imperial Airways, and, having passed through customs, be placed on the 12 o'clock machine. The consignor's agent in Paris, having been instructed by telegraph, would meet the machine at Le Bourget at about 2.30, receive his

samples, and, if necessary, display them to his prospective purchaser the same afternoon.

There is, of course, a considerable quantity of freight which is not dealt with by these express methods. The consignors are well content to get the benefit of the reduced handling gained by using the air route, and do not object to the delay (which is, in any case, less than that on the ground), caused by sending a quantity of freight on the normal services, and not augmenting the services specially to deal with it.

It may not be realized what a tremendous saving of customs delay is effected automatically by the use of air transport. The whole of the " en transit " clearance by agents, involved at every trans-shipment point in surface transport, is eliminated. Thus, goods consigned by air to Malmö, although transferred to a Swedish aeroplane at Amsterdam, do not come under the purview of the customs authorities in Holland. By the normal route " en transit " clearance would be involved at least at The Hook and at Esbjerg. The result is to achieve delivery in Sweden the day after consignment.

Special arrangements have been concluded with the railway companies for dealing with goods traffic on occasions when, as for example, in a period of thick fog, it proves impossible to fly. By virtue of these arrangements, no time is lost over the ordinary surface means of communication. A consignment of goods from Paris to London will illustrate the procedure. The goods, having been accepted for transport by Imperial Airways, are taken to Le Bourget, where it is ascertained that no flying is possible on account of fog. This may, of course, be ascertained before leaving Paris, but meteorological forecasts are not always sufficiently definite in the early morning to say what will be possible later in the day. However, when the fact is established, the goods are then taken to the Gare St. Lazare and placed on the Dieppe boat train. They remain marked " By Air," which secures for them special

treatment. They are not subject to customs examination at the ports, and on arrival in England they are again placed on the boat train, which is met at Croydon by the Lep Transport & Depository's collecting vans. This, of course, necessitates a special arrangement with the customs authorities, who authorize the passing of the goods through the customs post at Croydon aerodrome. From here, they are delivered in the normal way to consignees.

MAILS

Mails, which constitute the best paying class of air traffic, are dealt with under special arrangements by the G.P.O. Air mail matter may be posted at any post office, by the prepayment of a special fee (which in the case of a letter to Paris is 2d.) and the affixing of a special blue label—" By Air Mail." Leaflets giving the latest times of posting, fees, and time saved for the various places served by air mail are handed out to all inquirers at any post office. The mail so collected is taken by road to Croydon in time for each departure, and each incoming machine is met by the Post Office for the collection of inward mails. No doubt, in the future, this process will be simplified and expedited by the construction of a postal tube from the G.P.O. to Croydon, just as the great London railway termini are linked up with the Post Office. Unless an express delivery fee is paid, air mail matter is delivered by the first possible ordinary postal delivery. An interesting and useful feature of the parcels mail is the arrangement whereby parcels are accepted at certain post offices for express delivery in Paris by Imperial Airways, who undertake to clear the parcels through customs and deliver them personally on payment of an express fee.

A comparison of passenger fares with freight and mail rates is of considerable interest, and brings out some interesting facts with regard to the relative value of these different classes of traffic. Neither passenger fares nor freight rates are reduced to a common standard rate per

mile. They depend on the nature of the traffic available on different routes. On the London-Paris route, for example, there is a much greater amount of passenger traffic than on any of the other routes operated from London. This traffic consists largely of American tourists. The normal single fare for the journey of 210 miles is £6 6s., equivalent to about 7d. per passenger mile. The fare to Amsterdam, a distance of 250 miles, is £4 10s., equivalent to approximately 4½d. per passenger mile.

Again, since from Paris there are considerable consignments of light delicate articles of value, the freight rate on small parcels of less than 2 lb. in weight is 1s. per lb.; that, on large consignments of 1 cwt. or more is 3d. per lb. To Cologne, on the other hand, which is some 300 miles from London, and to which consignments of heavy goods, such as motor bicycles, have been frequent, the rate for small parcels is 9d. per lb., and for large consignments 5½d. per lb.

Now, if we again take London-Paris as our standard route for investigation, we shall certainly obtain figures more favourable to passenger traffic than on any other route, but the comparison will serve. The average weight of a passenger with his free allowance of 30 lb. of baggage may be taken as 200 lb. Consignments of goods of this weight would be charged at 3d. per lb. The rate paid by the post office for the carriage of mails varies with the class of mail matter, but in the case of ordinary letters to Paris it is 1s. per lb. We have, then, the following comparative figures per lb. for these different classes of traffic—

	s.	d.	
Mails . . .	1	–	per lb.
Passengers . .		7¼	,, ,,
Freight . . .		3	,, ,,

Table B (page 115) serves to give an idea of the passenger fares and freight rates prevailing and includes at the same time details of insurance premiums. Special rates are quoted for regular or large consignments, and it should also

TABLE B

Imperial Airways, Ltd.—Fares and Freight Rates

Freight not exceeding lb.	LONDON TO Paris D	Basle A	Zurich A	Amsterdam D	Brussels or Ostend A	Cologne A
	s. d.	s. d.	s. d.	s. d.	s. d	s. d.
2	2 —	2 6	3 —	2 —	1 6	2 —
7	3 6	5 6	6 —	4 8	2 10	4 6
11	4 10	8 10	9 9	6 9	4 —	7 6
22	9 —	17 —	19 —	12 9	8 2	14 2
33	11 6	23 2	24 9	16 11	10 4	18 8
44	14 —	28 3	30 6	21 1	12 6	23 2
55	16 4	33 4	36 2	25 3	14 8	27 8
66	18 8	38 5	41 10	29 4	16 10	32 2
88	23 4	48 7	53 2	37 6	21 2	41 2
112	28 —	58 9	64 6	45 8	25 6	50 —
Exceeding 1 cwt.	Per lb. 3d. (min. 28s.)	Per lb. 6d. (min. 60s.)	Per lb. 6½d. (min. 65s.)	Per lb. 5d. (min. 47s.)	Per lb. 2½d. (min. 25s. 6d.)	Per lb. 5½d. (min. 51s. 6d.)
Insurance premium (domicile to domicile in every case.)	2s. %	4s. 6d. %	5s. %	3s. %	2s. %	4s. %
Minimum premium	1s.	1s. 6d.	1s. 6d	1s.	1s.	1s. 6d.
Insurance premium by surface transport	6s. 8d. %	7s. 6d. %	7s. 6d. %	6s. 8d. %	6s. 8d. %	7s. 6d. %
Passenger fares	£6 6s.	£8 8s.	£8 15s.	£4 10s.	£4 (Brussels) £2 15s. (Ostend)	£6
,, insurance	1s. %	2s. %	2s. %	1s. %	1s. %	2s. %
Minimum premium	5s.	10s.	10s.	5s.	5s.	10s.

A. Aerodrome to aerodrome.
D. Domicile to domicile.

be noted that precious metals, precious stones, and similar articles are not accepted at these rates, but are charged for on an *ad valorem* basis.

Imperial Airways issue a very attractive time table, which includes all such information as fares, freight rates, and insurance rates. At the same time more general information covering the whole of the air services of Europe may be obtained from "The International Aerial Time Table," published monthly by Lep Transport & Depository, Ltd.

It remains to examine briefly the results which have been attained in the carriage of passengers and goods. Table C, page 117, shows the totals under various headings during the six years and some months from the time air transport was inaugurated in 1919, up to 1925. The table refers only to traffic between England and the continent; other transport on which British aircraft have been engaged has been relatively unimportant. Under the heading of "flights," "passengers," and "freight" are given the number of flights carried out, the number of passengers carried, and the weight and value of goods carried.

Comparing the years 1920 and 1925, it will be seen that the total number of flights carried out increased by about 60 per cent. The number of passengers carried, however, shows a rather more than three-fold increase. In other words, where in 1920, 1·8 passengers per flight was the average, in 1925 approximately four passengers per flight were carried—a point of some significance for the revenue returns.

Figures are not available for a similar comparison of the freight carried, but it will be noticed that the freight has doubled both in weight and value since 1922, the first year for which complete figures are available. In terms of load per machine flight, the freight carried in 1925 amounted to 400 lb. per flight, or the equivalent of two and a half passengers (in weight), in addition to the average of four passengers actually carried.

TABLE C

CROSS-CHANNEL AIR TRAFFIC: BRITISH AND FOREIGN

(Traffic between Great Britain and the continent only, i.e. excluding traffic on internal and foreign stages)

Year	Flights			Passengers			(A) Freight Weight			Freight value
	British	Foreign	Total	British	Foreign	Total	British	Foreign	Total	Total
							Tons	Tons	Tons	£
1919 5 mths.	467	64	*531*	870	52	*922*	(B)	(B)	(B)	*90,936*
1920	2,854	768	*3,622*	5,799	584	*6,383*	(B)	(B)	(B)	*1,028,812*
1921	993	2,404	*3,397*	5,256	5,475	*10,731*	(B)	(B)	(B)	*574,300*
1922	2,891	2,048	*4,939*	9,490	2,869	*12,359*	182·7	294·6	*477·3*	*713,020*
1923	2,559	2,016	*4,575*	11,947	3,189	*15,136*	326·5	498·9	*825·4*	*776,251*
1924	2,794	2,044	*4,838*	10,456	7,402	*17,858*	541·8	391·4	*933·2*	*1,350,960*
1925	2,891	2,399	*5,290*	10,602	10,119	*20,721*	454·8	437·9	*892·7*	*1,586,936*
Grand totals	15,449	11,743	*27,192*	54,420	29,690	*84,110*	(4 yrs.) 1505·8	(4 yrs.) 1622·8	(4 yrs.) *3128·6*	*6,118,215*

NOTE. (A) Excluding precious metals
(B) Totals not available

The distinction between "British" and "Foreign" in all cases refers to machines.

When it is borne in mind that the freight figures refer to ordinary freight only, and do not include precious metals, the carriage of which has greatly increased in recent years, it must be concluded that progress has, on the whole, been satisfactory.

CHAPTER XV

CONTINENTAL ROUTES AND TIME TABLES

THE location of the main air lines across Europe is governed by the position of the mountain groups, of which the one having the greatest effect is, of course, the Alps. Mountains of moderate height and extent do not constitute an impassable barrier to air transport. They increase the difficulties from several points of view, but it still remains possible to cross them. In the case of mountains whose peaks run up to 15,000 ft. and more, however, one has to admit that a barrier exists which cannot be crossed by load-carrying transport aircraft of the present day, and that even if the ceiling could be attained, too many other difficulties are introduced for the operation to be considered really practicable.

It also happens, for reasons of a similar nature, connected with the migration of tribes, that the majority of the important cities of Europe lie north of the Alps, on the Great Lowland Plain of Europe. This is fortunate for air transport, because it makes the provision of services where they are required more easy. The two factors together determine that the most important trunk air routes in Europe shall run from east to west. Other routes are required and are provided, which run from north to south, but these are subsidiary. The one important trunk route, which may in the future lie south of the Alps, is a seaplane route from Marseilles to Egypt. This is a section of the Empire route to India.

The first of the trunk routes is that from London via Amsterdam and Hanover to Berlin, with extensions eastward via Danzig and Moscow towards the Far East. The second is from London via Brussels, the Rhine towns, Munich, Vienna, Budapest, Belgrade and Bucharest to Constantinople, and thence again to the east, via India.

The first route lies wholly over the northern European plain, in country well suited geographically, if not meteorologically, for aviation. A considerable portion of this route is already in operation. Imperial Airways and the Royal Dutch Air Service (K.L.M.) operate between London and Amsterdam, providing at least two services each way daily. The K.L.M. and Farman Air Lines (France) provide services between Paris and Amsterdam, thus providing a second distributing centre (Paris) at the western end of this airway. From Amsterdam, the Deutsche Luft Hansa A.G. carry on to Berlin, and, in conjunction with a subsidiary company, operate a daily service from there to Moscow. This, at present, is the eastern limit.

This northern east-west route has several important lateral branches. The first connects at Amsterdam with Denmark, Norway, and Sweden. Services along this line, touching at Bremen, Hamburg, and Copenhagen, and reaching Malmö, in Sweden, are operated by the A.B. Aerotransport (Sweden), in conjunction with the Deutsche Luft Hansa A.G. The Danish Air Service Co. also operate as far as Copenhagen.

Berlin naturally is a big distributing centre for all the important towns in eastern Germany and Poland. The most important links, however, are those to Prague and Vienna, connecting with the southern east-west trunk route, and the line through Danzig and Riga, to Leningrad and Finland. Neither of these branches are completely operated at present, but the Deutsche Luft Hansa A.G. operate on the latter as far as Memel, and have plans for a service on the former, the limit at present being Dresden.

The second trunk route lies, in its central portion, over rather less favourable country for flying than the northern route. Lying over the northern outlying spurs of the central European massif, it crosses country of a more broken and more wooded nature. While the northern route lies wholly over one plain, an examination of a map will show that the southern route practically follows the

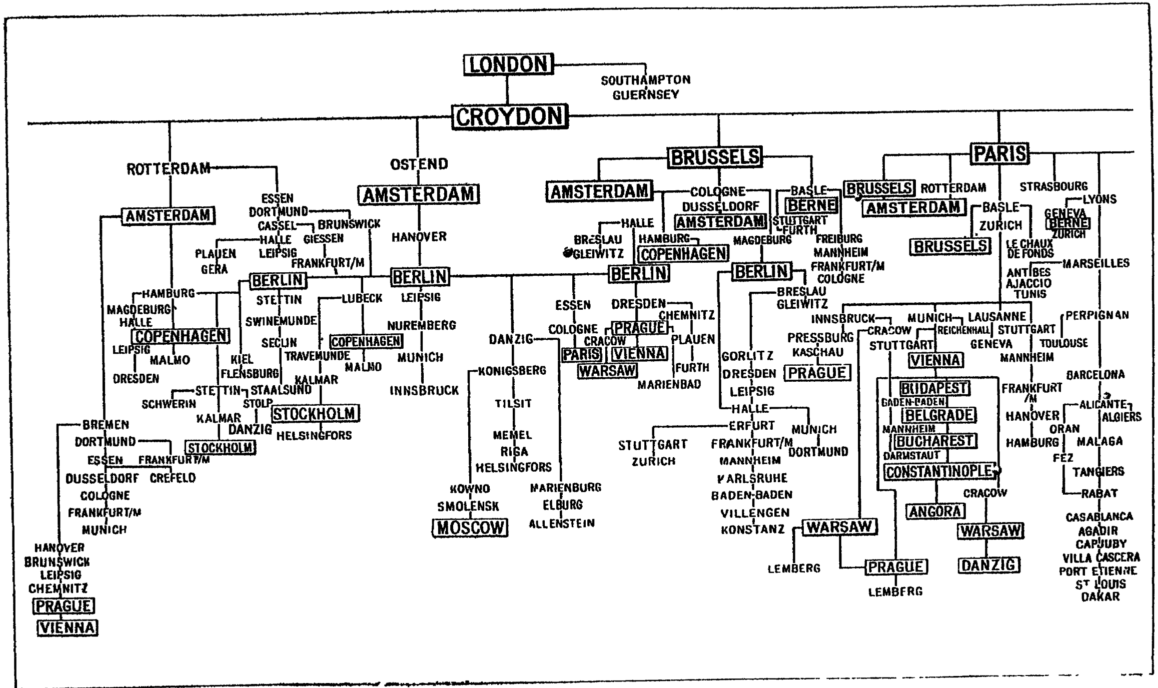


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FIG. 7. AIR SERVICES OF EUROPE

Danube valley (another old migratory route) and crosses a series of plains divided by mountain chains. Chief of these are the Hungarian Plain and the Wallachian Plain (Rumania), and the mountain systems are the Bohmer Wald, the Carpathians, and the Balkans.

The plains are the centres of population, and contain the principal towns, and we therefore find a tendency for branch routes to originate in the plains, often to connect one with another. Thus, from Vienna a branch will run north to the towns of the Bohemian Plain—in short, to Prague. Again from Vienna, a route will run south-west to the towns of the Plain of Lombardy—in short, to Italy.

It is of some importance to note the alternative base at the western end of this route, with the branch line from Strasbourg to Paris. This route from Paris to Constantinople has been operated spasmodically by a French company—the Cie Franco Roumaine, but owing to the difficulties with regard to flying over Germany, operations had to be suspended. The successors of the company—the International Air Navigation Co., operate from Paris to Angora via Zurich, Vienna, etc. This route cannot be regarded as permanent on account of the natural difficulties created by the Alps.

Italy is so isolated by the Alps that there is, at present, not a single air service connecting Italy with the rest of Europe. The Alps will remain a barrier for some time. Nevertheless, Italy will occupy an important position on the Mediterranean east-west route when commercial flying boat services are commenced. A few boat services are operated at present in the western Mediterranean. The most important of these is Antibes-Ajaccio-Tunis operated by the French company "L'Aéronovale." North-south flying-boat routes in the Mediterranean, however, are clearly not of the same prime importance as the east-west route.

An important route, which might almost be given the dignity of being called a trunk route, though it runs from

north to south, must be mentioned in any general survey of European air routes. This is the line at present operated by the French Latécoère Company from Toulouse to Dakar, in West Africa, via Barcelona, the east coast of Spain, Tangier and Casablanca. This service has had

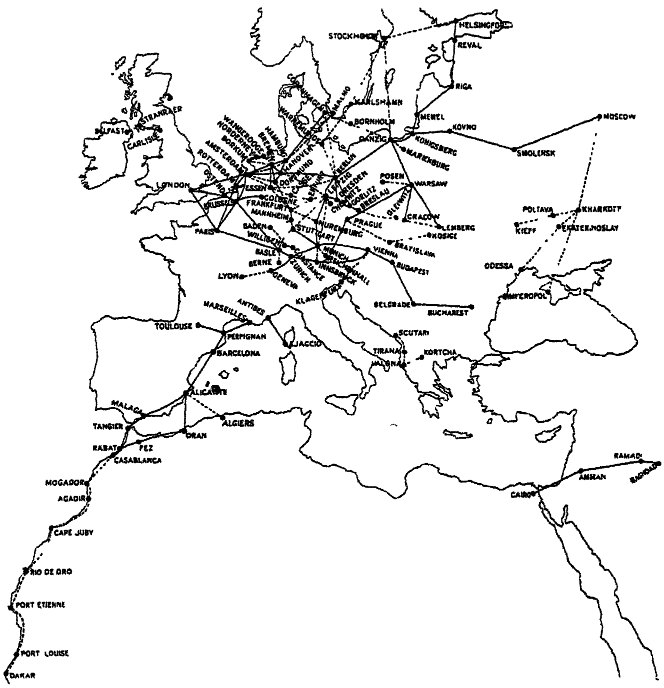


FIG. 8. PLAN SHOWING GROWTH OF AIR ROUTES IN EUROPE AND ADJACENT TERRITORY DURING 1924 AND 1925

The routes shown in continuous lines were in operation during 1924, while those shown in dotted lines were added during 1925.

very considerable success over a number of years, and is particularly noteworthy for the quantities of mail carried. The saving in time shown by such a route is naturally great. When this route is connected to South America by a service of fast steamers from Dakar to Pernambuco, it

will become one of prime importance in the communications of the world.

It is not one of the functions of this book to serve as a time table of air services. Readers who wish for more detailed information can get it from the time tables issued by Imperial Airways, Ltd., or from the International Aerial Time Table. An excellent idea of the services in operation in May, 1926, and the way in which different European towns are interconnected by air is given in the synoptic table which appears on page 121, and which is reproduced from the International Aerial Time Table by the courtesy of the Lep Transport & Depository, Ltd.

A study of the map of European air routes operated in 1925, reproduced on the previous page, will show how the trunk routes, referred to above, are developing. The map is designed to show the increase in the services in operation in 1925, as compared with 1924.

CHAPTER XVI

AIRCRAFT AND ENGINES

AIRCRAFT

AIRCRAFT may be divided into two main categories—airships and aeroplanes.

It is not proposed to deal with the former in this work beyond a slight reference to them in the chapter dealing with "Technical Development," for the reason that, up to date, no experience has been gained in the commercial operation of airships in this country, and, consequently, any statement which could be made would be based on theory rather than on practice.

Aeroplanes are separated into two general classes; the land machine, which is generally referred to as an aeroplane, and the sea-going machine, which is usually known as a seaplane, and may be of two types, either the float or the boat type, the former being more or less similar to the land machine, except that in place of landing wheels it is provided with floats, while the latter is entirely different, the whole of the fuselage and undercarriage, including the landing gear, being replaced by a boat-shaped hull.

Dealing with aeroplanes, by which is meant in this instance, both the land machine and the sea-going craft, they may be divided generally into two types—the single-engined machine and the multi-engined machine.

Opinions as to the advantages of one type over the other are divided, but if a vote was taken it would probably be found that those in favour of the multi-engined type largely predominate.

The latter may be fitted with either two or more engines, usually two or three.

Now, let us consider the advantages and disadvantages of these varying types.

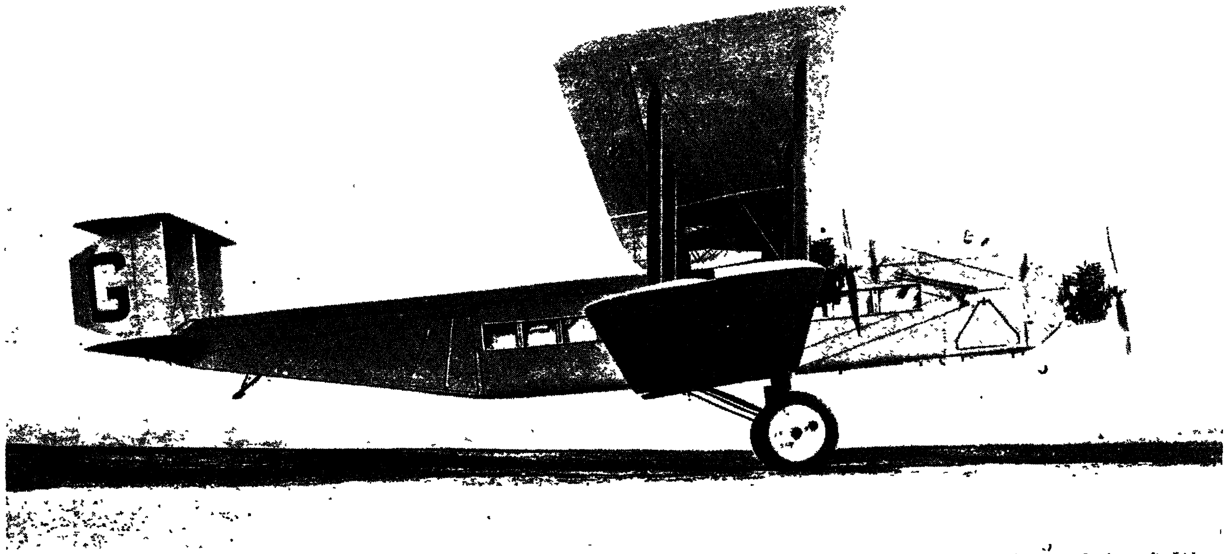
The main advantage which can be claimed for the

single-engined machine is that only one set of accessories in the form of various component parts which, together, make up the engine installation, such as engine controls, petrol feeds, etc., is required, and that as the cause of so-called engine failure is, in the majority of cases, due to failure of some part of the installation rather than to defects in the engine itself, by adopting the simplest form of power plant possible, which is clearly the single-engine plant, the causes of failure are reduced to minimum proportions. Against this, however, must be set the tremendous disadvantage that when a failure of the engine or installation does occur, there is no alternative to an immediate landing, which gives only limited opportunity to choose a good landing ground.

Moreover, since air transport has to be conducted in all conditions of weather, fine or foul, and since the single-engined machine gives the pilot a limited scope for choice of landing grounds in case of engine failure, it naturally follows that, in bad weather conditions, pilots of single-engined aircraft favour low flying so as to keep, as far as is possible, in sight of the ground in order to minimize the risk entailed in a forced landing in bad visibility. Further than this, when low-lying clouds or fogs are prevalent, the single-engined pilot hesitates to climb above into the sunshine because, in the event of engine failure, he does not know what is underneath. He may be flying over high country which joins the fog or cloud, in which case the chance of his flying into trees, houses, or other obstructions when landing, are as great if not greater than are his chances of landing on suitable ground.

Now, let us consider the multi-engined machines. As has already been mentioned, they may be twin-engined, three-engined, or they may even be fitted with four or more engines.

The twin-engined machine, to achieve any advantage over the single-engined machine, must be capable of flight with either one of its engines cut out. This does not mean that



By courtesy of *Sir W. G. Armstrong Whitworth Aircraft, Ltd.*

FIG. 9. ARMSTRONG WHITWORTH "ARGOSY"

A twenty-passenger aircraft fitted with three 385 h.p. Armstrong Siddeley Jaguar engines

it must be able to maintain its height with a full load, but it must be manoeuvrable and controllable when flying on one engine only.

It is true that the chances of installation or engine failure are doubled with the twin-engined aircraft as compared with the single-engined machine; they may, in fact, be even more than doubled owing to the extra complications involved in the double installation. So far, then, nothing is gained. The advantage lies in the fact that, as it is highly improbable that both engines or installations will fail at the same time, half the total engine power will almost always be available, and even though this may be insufficient to maintain flight with a full load without loss of height, the angle of glide will still be sufficient to give the pilot in fine weather ample opportunity to choose a suitable ground on which to make a forced landing with perfect safety, and even in foggy weather will considerably increase his chances of reaching an aerodrome or emergency landing ground.

A twin-engined machine which is uncontrollable with one engine cut out, obviously possesses no advantages over the single-engined machine; on the contrary, it is less desirable, since the chances of engine or installation failure are at least doubled.

Now, consider for a moment the machine equipped with three or more engines. Here it may be taken as axiomatic that unless such an aircraft can fly with a full load when one of its engines is out of action, no advantage is to be gained over the twin-engined aircraft. Such a machine need not be considered, however, since the sole object of fitting a machine with three or more engines is to give it reliability. Here, again, it is highly improbable that more than one engine or installation will fail at the same time, and since an efficient three-engined machine can maintain its height with a full load with one engine cut out, it follows that a forced landing should never take place, in other words, it should never be necessary in such an aircraft to land anywhere except on an aerodrome.

The advantages of this are probably obvious in so far as safety is affected, but there is a further benefit to be gained in connection with reliability which is not so self-evident. This concerns fog and cloud flying. So long as a pilot of a three-engined machine knows that his aerodrome of destination is not fog bound, the conditions on the rest of the route are more or less immaterial, since he knows that even with one engine out of action, the remainder will carry him on to his destination, and, consequently, there is no restraint to his flying above the fog or clouds, which not only adds immensely to the comfort of travel, but also increases safety and adds to the measure of reliability. Aircraft fitted with more than three engines, assuming that they are of efficient design, suffer from the same defects and reap the same advantages as the three-engined type of machine. For every advantage gained there is generally something lost, and this is true of the three-engined machine. The fact that the machine can fly on any two of its engines proves that, when all three are functioning properly, more power than is required is available, and, consequently, unnecessary weight is being carried in the spare engine. This necessarily causes a corresponding reduction in the paying load. As a set-off against this, however, each of the three engines can be throttled down to an extent which would not be possible with less than three engines, with the result that the wear and tear on the engines is reduced with a proportionate reduction in maintenance costs, and it is highly probable that this saving in operating costs may more than counteract the loss of revenue occasioned by cutting down the carrying capacity. Only experience, which is at present lacking, can prove this.

Before leaving this subject, its bearing on the important question of fuel consumption may not be out of place.

It might naturally be assumed that a machine which is fitted with three engines will use 50 per cent more fuel than a more or less similar one which is fitted with only two, assuming that in each case, the same type of engine

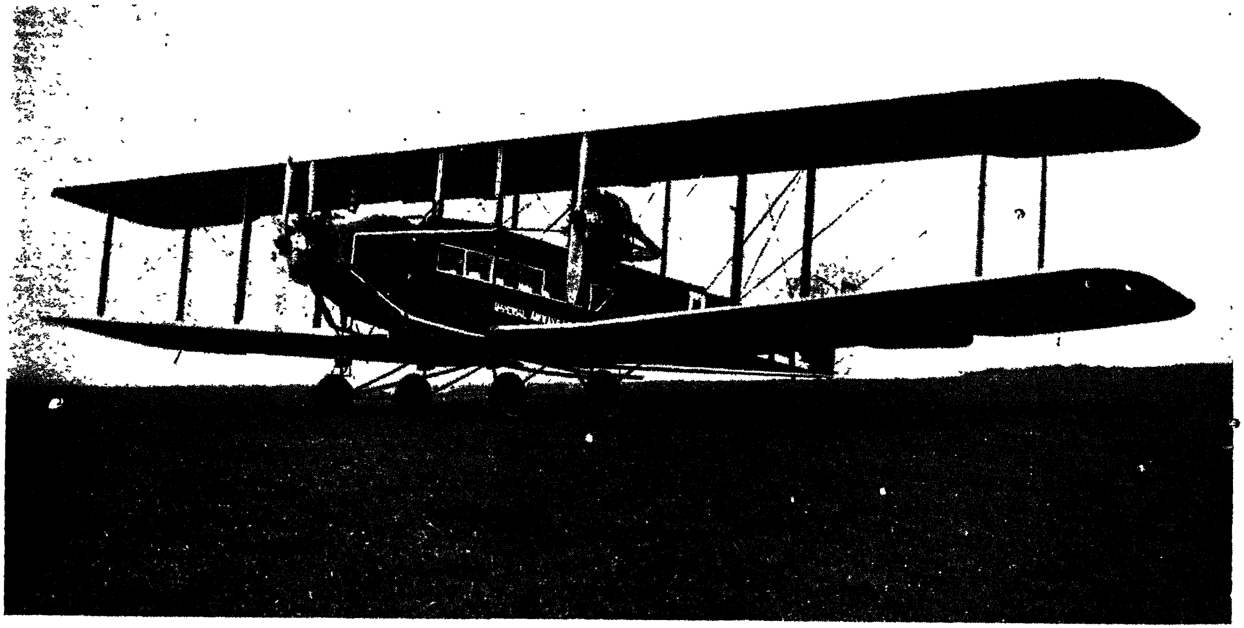


FIG. 10. HANDLEY PAGE "HAMPSTEAD"
A sixteen-passenger aircraft fitted with three 385 h.p. Armstrong Siddeley Jaguar engines.

is used. Actually this is not so, because, provided that in each case the machine is designed to carry the same load, the same amount of power must be developed to maintain it in flight, and, in consequence, the three engines in the one case will probably be throttled down to give the same output of power as the two engines in the other. Now, since fuel consumption is almost directly proportional to power output, it follows that the difference in the amount of fuel used in the two types will be negligible.

A further classification of aircraft divides them into monoplanes, biplanes or multiplanes, the latter being rarely employed. A considerable amount of doubt exists among British designers and aëronautical scientists as to the relative advantages or disadvantages to be obtained by using the monoplane form of construction. Many continental designers of great repute favour the monoplane, claiming for it simplicity of construction, reduction of head resistance due to the elimination of interplane struts, bracing wires, etc., and cheapness of maintenance. As this form of design has never been seriously adopted in this country for commercial aircraft, no reliable data exist on which to base a definite conclusion as to the relative advantages of one type over the other. There seems little doubt, however, that maintenance costs, which form a very heavy item of expenditure in the operation of air transport, could be substantially reduced by the adoption of the monoplane, especially when combined with metal construction in large-type machines.

Here let us consider a further major classification of aircraft by dividing them into those made in wood and fabric, and those constructed in metal.

Up to date in Great Britain, nearly all designers have used the former materials with which to build their aircraft. The main reason for this has been that until recently, insufficient knowledge existed concerning the properties and the methods of working light-metal alloys and high-grade steel, such as might be suitable for use in aircraft

construction. Secondly, the expense involved in building a few machines of a type, in metal, is far higher than is the case with wood and fabric; and, thirdly, being a conservative race, it has been difficult to break away from the use of the materials which have been associated almost universally with aircraft construction. Moreover, until thorough investigation proved that it is possible to build metal aircraft weighing no more than similar machines made of wood, it was generally believed that, from a weight point of view alone, the use of metal in aircraft construction was impossible.

There is now no doubt that given a large type machine, it can be built as lightly, or even more lightly, in metal, as in wood and fabric.

It is impossible, on the insufficient experience accumulated up to date, to base a definite ruling as to whether maintenance charges will prove to be as great or less with the all-metal machine, but everything points to a marked reduction being obtainable in this respect. This is of the utmost importance, as maintenance charges represent a very large proportion of operating costs. In tropical climates it is anticipated that with wood and fabric construction this item of maintenance will rise to a prohibitive figure. On the other hand, in the event of serious damage, the wood and fabric machine is infinitely simpler to repair locally, extensive damage to a metal machine generally necessitating its return to the manufacturer. When sufficient aircraft are in use, the necessary establishment of efficient workshops will cause the disappearance of this last defect.

With regard to aircraft fitted either with floats or boat bodies, metal construction is undoubtedly an advantage, in that the soakage of a wooden hull is a very serious item, and frequently accounts for a loss of several hundred pounds weight of paying load after only a few months service.

The size of aircraft is steadily growing, and this increase will undoubtedly continue. Even with machines of the wing span as now used, the question of housing is becoming a very serious problem, and the day cannot be far distant when

By courtesy of *Imperial Airways, Ltd.*

FIG. 11. HANDLEY PAGE W.10, INTERIOR

A view of the cabin (looking aft) of one of the latest Imperial Airway passenger aircraft

all large-sized aircraft must live permanently in the open, sheds to be used for overhaul purposes only. This necessarily points to the conclusion that metal must be the material used in the construction of these large-type machines.

As traffic grows, so naturally will the number of aircraft to cope with it also have to be augmented; doubtless they will be enlarged in size, but it is certain that they will be increased in number. It is generally agreed that mass production will be simpler, cheaper, and a more rapid process in metal than in wood. There is a school which favours the whole of the framework of machines being constructed in metal while the outer covering is made of fabric. The arguments in favour of this form of construction are that it simplifies repair to structural damage, and at the same time allows of easy and thorough inspection; moreover it is lighter. This last argument, however, does not hold true of all systems of metal construction, and completely debars that form in which the outer shell supplies, if not the majority, at least a very large part of the structural strength of the machine. When considered from every aspect, and the advantages and disadvantages of the two classes of construction, metal and wood, weighed up, the balance is certainly very largely in favour of the former, and it can be stated, with considerable assurance, that for air transport purposes, the days of the wooden machine are numbered.

Brief reference has been made to the seaplane and flying boat. Up to date, air transport has been mainly confined to the use of land machines, and the reasons for this are not far to seek. Seaplane floats, or a boat hull, add appreciably to the weight of a machine of the size at present in use, and as it is most desirable that the greatest possible paying load per unit of horse-power shall be carried, sea-going craft have not generally been looked upon with favour by operators. It is by no means certain, however, that the conditions affecting weight will continue, especially with regard to flying boats, and as sizes increase within certain

limits, it is more than probable that it will be possible to build this type of machine lighter than the land machine. Beyond a certain size this is unlikely to hold true, the reason for which at first sight appears to be illogical, viz., that as the sizes of flying boats reach really large dimensions, it is necessary to strengthen the hull, in order to be able to withstand the shock caused by striking the water at the moment of landing, to such an extent that the weight involved in the hull structure increases at a greater rate than the paying load; consequently there is a limit in size beyond which it is uneconomical to build a flying boat.

In spite of the disadvantages associated with marine aircraft, there are other factors to be considered, which may, in many cases, render it desirable that they should be used; for example, on routes which involve long sea flights, or on those which follow a mountainous or difficult coast line which is badly supplied with land communication, or again on those which cross country mainly composed of forests and lakes. The cost of providing the necessary ground organization on many land routes would be prohibitive, and in such cases it will be cheaper in the long run, and generally safer to operate with the more expensive type of aircraft. It may be accepted that in ninety-nine cases out of one hundred, a sea route is infinitely cheaper to prepare, equip, and maintain than a land route; consequently where a choice of either one or the other exists, every aspect must be considered before a decision is reached as to whether land machines or sea-going craft are to be employed.

ENGINES

Engines fall into two main classes, air-cooled and water-cooled. Of the former, three types exist—the rotary, the radial and the stationary vertical or "V" type. In the rotary engine, the cylinders and the casing in which they are mounted revolve, while in the radial, although in general outward appearance there is a certain amount of

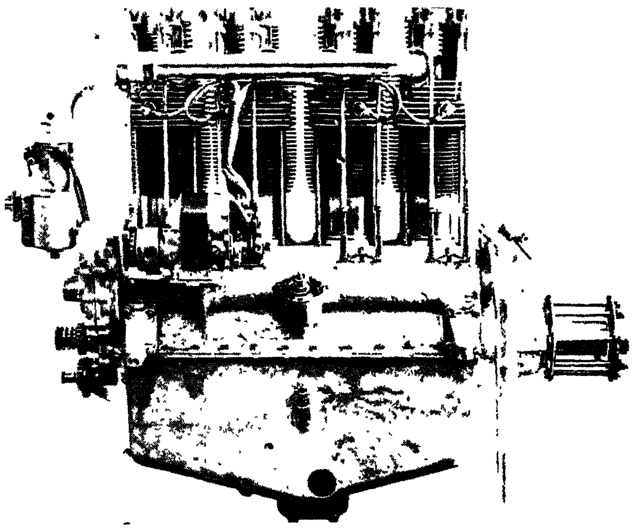


FIG. 13. TYPES OF AIRCRAFT ENGINES
The 60 h.p. A.D.C. Cirrus engine: air-cooled, vertical type

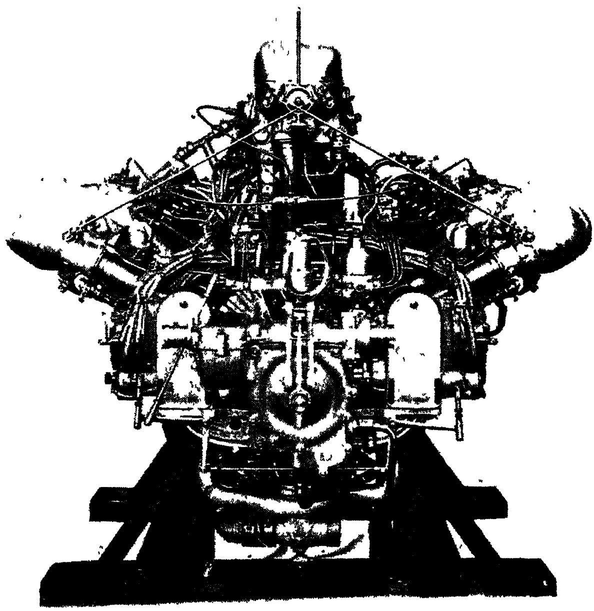


FIG. 14. TYPES OF AIRCRAFT ENGINES
The 450 h.p. Napier Lion engine: water-cooled, V type

resemblance to the rotary, the cylinders are stationary and fixed as in the normal type of engine. The stationary vertical or " V " type air-cooled engine is too well known to need any description.

Generally speaking, provided that equal efficiency and reliability is obtained from either an air-cooled or a water-cooled engine, the former is preferable for the purposes of commercial aviation. The reasons for this are fairly obvious.

The goal to be arrived at is economy in weight and the elimination of unnecessary complications. It is clear that the water-cooled engine needs such adjuncts as radiators, water-jackets, and the water itself, all of which add considerably to the total weight of the engine and its installation. A large proportion of failures with the water-cooled engine are attributable to faults in the installation or accessories, rather than to the engine itself, and the majority may be traced to the cooling system.

The air-cooled engine dispenses with radiators, water-jackets, water, etc., and in consequence a considerable amount of weight is saved. Moreover, owing to the absence of these complications, the air-cooled engine is less liable to trouble, since the very parts which normally are the seat of it are absent from its construction.

Dealing with the three types of air-cooled engine, it is unnecessary to consider the " rotary " engine from an air transport point of view on account of the fact that it is not designed to give the power required for use in commercial aircraft. There remain therefore, only the stationary and the radial.

With the former the main difficulty is adequate cooling, since clearly, the cylinders which are in front blanket those behind, in addition to which it is very difficult to obtain lightness. With the radial engine these drawbacks largely disappear. The very shape of the engine lends itself to lightness of construction by the elimination of large crank-cases, sumps, etc., and owing to the position of the cylinders,

the cooling problem is simplified. Here the main difficulty lies in the fact that the front of the cylinders being directly opposed to the cooling air through which the machine is

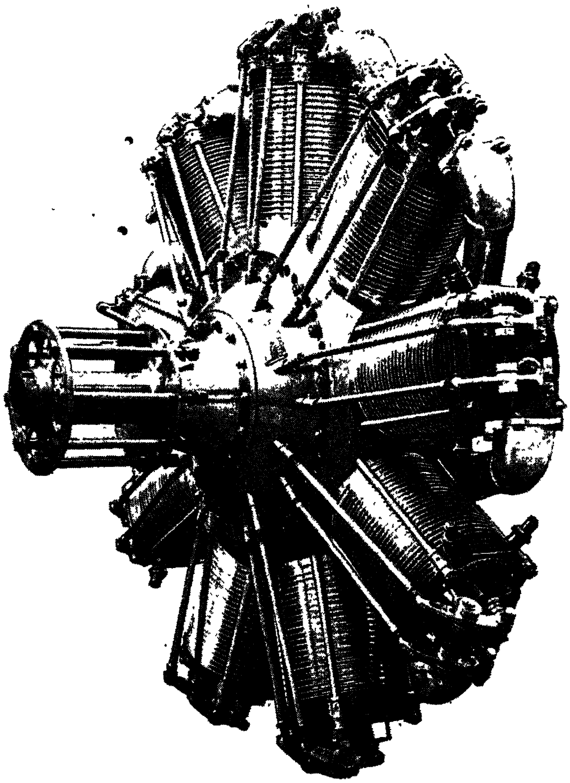


FIG. 15. TYPES OF AIRCRAFT ENGINES
The 200 h.p. B.R.II engine (Bentley Rotary): air-cooled, rotary type

travelling, while the rear portion is in what is almost a vacuum, there is a tendency for the expansion of the front and rear portions of a cylinder to be unequal. Careful design has, however, largely eliminated this difficulty, with

the result that to-day the radial air-cooled engine is rapidly gaining in popular esteem and general use.

The main disadvantage of the radial air-cooled engine is the difficulty of providing it with adequate silencing.

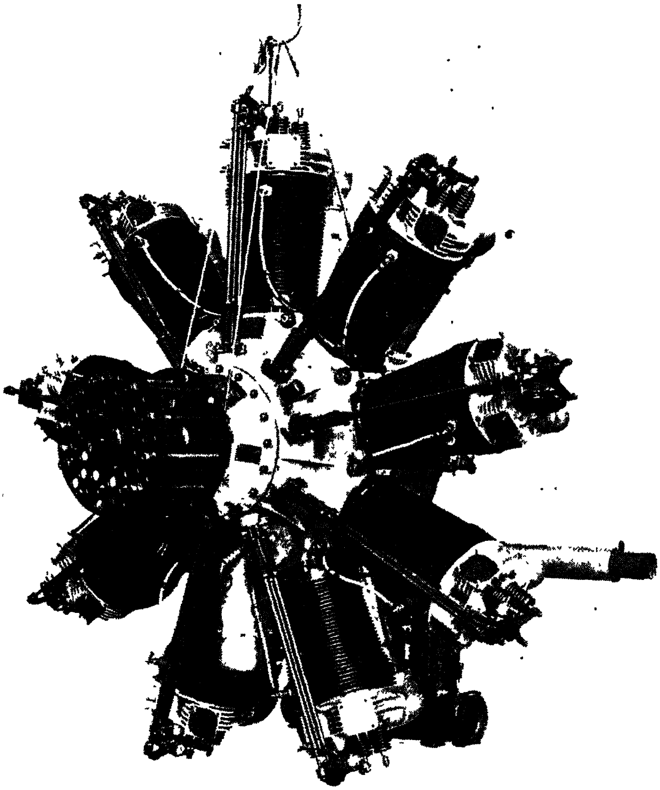


FIG. 16. TYPES OF AIRCRAFT ENGINES
The 380 h.p. Bristol Jupiter IV: air-cooled, radial (stationary) type

To sum up, it is considered that the development of aircraft for purposes of air transport in the near future lies in large monoplanes of all-metal construction, fitted with three or more radial air-cooled engines.

CHAPTER XVII

TECHNICAL DEVELOPMENT

INVESTIGATION, experiment, and research are being carried on continuously in every single branch of aeronautical science with a view to increasing the efficiency of aircraft from an operational and economic point of view, improving safety and reliability and adding to the comfort of air travel.

So many subjects are being attacked that it is impossible, with clarity, to classify them into definite categories. The best that can be done is to attempt to divide up the objects which it is desired to achieve and then to deal with all the main technical developments which are in progress in connection with each particular object, as follows—

1. Elimination of the difficulties inherent in fog and night flying.
2. Improvement in aerodynamic qualities of aircraft.
3. Reduction of operating costs.
4. Increase of reliability of aircraft and engines.
5. Improvement of comfort in aircraft.

Dealing with the first of these subjects, "Elimination of the difficulties inherent in fog and night flying," it has already been explained what the effect on air transport will be when flight through fog or darkness becomes a normal part of regular operation.

Clearly, the first object to be achieved is the provision of absolutely reliable aircraft. As, however, this subject is dealt with under the fourth heading, no further reference will be made to it here.

The next object is the perfection of ground organization specially designed to assist an aircraft in fog or darkness; and, lastly, the provision of adequate instruments, etc., in aircraft, either to work in conjunction with the ground installations or independently to assist in navigation.

As far as ground organization is concerned three main avenues are being explored, namely, development of wireless, position indicating devices, and ground lighting. The two former are being developed hand in hand with instruments to be carried in the aircraft which will work in conjunction with them.

Three systems of wireless aids to navigation are being developed. The use of these is described in the chapter on "Navigation," and they will consequently only be referred to here.

Next we come to the position indicating device. This is known as the "leader cable," and consists of an endless cable buried just below the surface of the ground, through which an alternating current is passed. It is the intention that this shall be laid, part of it outside the aerodrome and part of it in a straight line down the best landing run of the aerodrome. In the pilot's cockpit a detecting instrument is fitted which does two things; firstly, shows the pilot if he is flying over the cable and if he is not, whether he is to the right or the left of it; and, secondly, shows him his height above the cable. This is done by an arrangement of two lights which oscillate up and down vertical tubes between which a height scale is mounted, the oscillations taking place either in unison or in opposition to each other; according to the manner in which the lights move, the pilot is informed of his position relative to the cable, and of his height above it.

Experiments are being carried out in other directions in an attempt to devise a system by which a pilot flying over unknown ground, which is hidden from him by fog or darkness, can find out his exact height above it at any moment. The reflection of sound or echo is the basis of this line of research.

Ground lighting covers a wide field. Experiments with different types of light beacons, searchlights, lighthouses, obstruction lights and aerodrome illuminating lights, are being carried out continuously. The most interesting, and what is likely to prove the most valuable of these,

is an adaptation of Neon light to aeronautical use. This takes two forms, one, a beacon to which detailed reference has been made in the chapter on "Night Flying," and the other by laying lengths of Neon tubes on the best landing area of an aerodrome in the form of an eight-armed star, the tubes being sunk under the ground and covered with plate glass flush with the surface.

Extensive experiments, carried out by the aid of a balloon, have proved that Neon light possesses the desirable quality of fog penetration to a marked degree, and that even with solid banks of fog 600 ft. or more thick, the upper surface of the fog will be brilliantly illuminated with the characteristic rosy pink colour which is emitted by Neon light, while the whole of the fog area above and in the neighbourhood of the tubes is filled with a most conspicuous and unmistakable red glow. Beside this, each individual tube of light is clearly visible from 150 ft. in the densest fog. It is intended to lay one arm of the star comprising this installation close to and parallel with the leader cable, already referred to, and to use these two in conjunction with wireless wing coils. The sequence of events will then be that a pilot will fly to an aerodrome by use of the wing coils, till he is within range of the activity of the leader cable, over which he will fly, while gradually losing height, until he comes within the glow of the Neon light, when he will land, using the tubes themselves to show him the ground.

An aid to landing in darkness, which is being developed in this and other countries, is in the nature of a glorified car headlamp. It is as yet uncertain whether this will prove effective.

Two of the many difficulties which are experienced when flying in fog, are to keep a machine on a level keel and on its course. To facilitate this, various instruments have been devised which are known as "turn indicators." The majority of these depend on gyroscopic action and indicate to the pilot whether he is keeping a straight course or turning either by means of pointers or by lights.

In order to give a pilot warning when he is approaching stalling point, that is to say, when he is flying at a speed only just above that necessary to maintain his machine in controllable flight, certain devices have been designed which are known as "stall indicators." These are operated by a small vane mounted more or less horizontally in a fore and aft direction on a convenient fitting near a wing tip. As the machine approaches stalling point this vane tips up, and either completes an electric circuit which lights a lamp in front of the pilot's face, or operates through valves and pistons in such a way that a slight pressure in a forward direction is put on the control column, thus giving the pilot an indication that he is approaching minimum flying speed.

Now let us review some of the developments which are connected with the second item of classification, "Improvement in aerodynamic qualities of aircraft."

These may be divided into two main groups, those which concern the structural design of the aircraft and those which are accessories to the aircraft. Under the former heading may be included, wing slots, variable camber wings, wing flaps, differential aileron control and design in which the size of the control surfaces and their relative distances from the centre of gravity produce the maximum amount of controllability.

All of these devices and systems of construction are designed to produce in an aeroplane the maximum amount of control at its minimum flying speed, and when it is flown below this speed, that is to say, when it has stalled, to ensure that it will not develop a spin, but will merely drop its nose and regain flying speed and again become fully controllable. Each of the above mentioned lines of development is entirely different, one from the other, but all are based on the same principle, which is to provide a means of securing additional control when the centre of pressure moves beyond safe limits.

The most promising developments which fall within the category of accessories are the gyro-rudder control, the

gyro-aileron control, and the pendulum-aileron control. These are automatic devices which operate either the rudder or the aileron in such a manner that they correct any change of direction or lateral balance which momentarily occurs, without any action on the part of the pilot. All modern commercial aircraft are fitted with adjustable tail planes, by means of which a pilot can set his machine to fly so that it will maintain horizontal flight with little attention. When in addition an aircraft is fitted with the above mentioned devices, she can fly herself almost unattended. These inventions, combined with one or more of those already mentioned as forming part of the structural design of the aircraft, when fitted to a three-engined machine which is aided by the wireless and other devices to which reference has already been made, will, when perfection is reached, render flying in fog or by night as simple and safe as it is to-day under the most ideal conditions.

Under this heading of "Improvement in aerodynamic qualities of aircraft," must be mentioned one entirely new form of aircraft and another, a development of a type with which experiments were made just before the war. These are, respectively, the La Cierva Auto-Gyro, and the Hill Tailless Monoplane.

The former, the invention of a Spanish designer, involves a radically new principle since it has no planes in the ordinarily accepted sense of the word. Instead, in a normal type fuselage fitted with the usual engine and airscrew, the wings are replaced by four horizontal planes mounted at right angles to each other on a vertical pillar just in front of the centre of gravity. These planes, in the nature of a windmill, are free to revolve without any mechanical assistance. Besides being free to revolve they are also hinged in such a manner that they can move up and down, a limit being placed on downward motion, when at rest, by check wires.

As soon as the machine moves forward under the action

of the airscrew, the planes revolve, and when they have attained sufficient speed, bear the weight of the machine, the planes remaining approximately horizontal owing to centrifugal force. Irregularity in air pressure or density, which would normally cause "bumps," merely causes the plane affected to move up or down, as the case may be, without affecting the stability of the machine. The main advantage of this machine over the normal type is that, while being perfectly controllable and capable of carrying out the normal evolutions required of an aircraft, it can descend at a very steep angle, and only runs a few yards after touching the ground.

In the experimental types so far produced, lateral stability is obtained by ailerons mounted on tubes in the position which they would occupy in a normal type aircraft, while fore and aft and horizontal stability are maintained by the usual rudder and elevator. It is too early yet to say to what developments this invention may lead.

The Hill Tailless Monoplane is also of an unusual type. It has no fuselage behind the trailing edge of the centre section of the plane, and has no rudder or elevator in the ordinarily accepted sense of the word.

The wing tips, which are swept far backwards, are fitted with ailerons and also with directional control surfaces which take the place of the normal rudder. The experimental machine built to this design has proved to be perfectly controllable and manoeuvrable under all conditions, and in common with the auto-gyro is practically unstallable. Here, again, until further experiments have been carried out with this design, it is impossible to predict what its future may hold.

In connection with the third item of classification, "Reduction of operating costs," numerous developments are taking place in many different directions.

As has already been explained the main items of expenditure in the operation of aircraft are—

Insurance of aircraft and engines,

Obsolescence of aircraft and engine
Maintenance ,, ,, ,,
Wages.
Fuel consumption.

Insurance of aircraft is dependent mainly on capital cost, maintenance, and reliability.

Obsolescence is affected by capital cost, maintenance, and rate of progress of development in design.

Maintenance is dependent on the form of construction, the material employed in construction, and the ease with which repairs can be carried out.

Wages are dependent to a certain extent on the amount of labour required to carry out overhaul and repair.

Fuel consumption is entirely connected with the engine. In addition, the pay load which can be carried per unit of horse-power has an important bearing on cost of operation. To sum up, therefore, the main items of a technical or material nature on which development must be concentrated in order to bring about a reduction of operating costs, are: Reduction of capital cost, increase in reliability, improved forms and methods of construction which will minimize replacements as far as possible, simplify repair, overhaul and inspection, and reduce the man hours required to carry out maintenance work to a minimum, reduction of fuel consumption and fuel costs, and, lastly, the development of aircraft which will carry as great a load per horsepower as possible.

The panacea for the high capital cost of aircraft is quantity production, which is dependent on the demand created by the opening up of new and more frequent services. Simplicity and standardization of design will also play its part. Efforts are being made to achieve the former, but the time is not ripe for the latter. Nevertheless, a certain amount of progress is being made in standardization in so far as it applies to fittings and component parts.

Technical research is being carried out throughout

Europe and in the United States of America on numerous kinds of metal alloys and high-grade steels which might be rendered suitable for the building of aircraft. Methods of treatment and experiments in various forms of metal construction are being made in this country, while on the continent and in America, many systems have now been adopted by different designers as their standard methods.

There can be little doubt that when more experience has been gained in the use of metal, and it has become possible to standardize to a certain extent fittings and component parts, the cost of production will be reduced. This will have its effect on the cost of maintenance, since the cost of spare parts required for replacements will fall in proportion as the capital cost falls.

Great scope for improvement, which calls for urgent attention, lies in what may be described as the haphazard method of putting aircraft together. By this is meant that insufficient attention is paid to the details of design from a maintenance standpoint. For example, it is frequently found that in order to remove one simple part, it may first be necessary to remove two or three others; complicated systems of fitting may be adopted when there is no necessity for it. Such things as grease caps are used when a grease gun would be far more effective, and so on. The ideal air transport machine from a maintenance point of view is one in which replacements and repairs can be made in the shortest possible space of time. Labour is too expensive to be wasted needlessly, and, moreover, the longer it takes to overhaul a machine, the less time it has in which to be flying. Slight improvement in this connection is taking place, but the advance which is being made falls far short of that which its importance warrants.

Constant endeavour is being concentrated on the problems connected with the increase of the pay load per horsepower which an aircraft can carry. Now, since the pay load is the difference between the total load which an aircraft can carry, including its own weight, and its own

weight including fuel, weight of pilot, etc., it follows that in order to increase the load per horse-power of a machine, it is necessary either to improve its aerodynamic efficiency so that for a given horse-power the total load which it can carry may be increased, or the total structure weight of the machine, including its engine, accessories or fuel, must be decreased.

Development is proceeding in both these directions. Aerodynamic efficiency is progressing slowly yet steadily. The adoption of the devices mentioned earlier in this chapter in connection with stability, namely, slotted wings, variable camber wings, and wing flaps, are likely to play a not unimportant part in this direction. The perfection of variable pitch propellors, supercharged engines, engines fitted with two-speed gears and bifuel systems of carburation will also do much to increase efficiency.

Decreased weight must be sought in four directions, namely, reduction in the weight of engines, of the structure of the machine, of accessories, instruments, etc., and in the fuel. The line on which development is taking place towards reduction of engine weight is by increasing the power output of a given engine; thus, although its weight remains constant, its weight per horse-power decreases.

Improvements in methods of construction are slowly bringing about a saving in structure weight. Instruments and accessories are constantly being lightened while fuel economy is being sought by improvement in engine design.

Each of these developments is tending to increase carrying capacity for a given output of power, and success in this direction will have a marked effect on the reduction of operating costs.

Now, let us consider the fourth item of classification, "Increase of reliability of aircraft and engines." Reliability of an aircraft, provided that it is of sound design and construction, is almost entirely dependent on the engine.

The progress which has been made in engine design within the last few years is little less than marvellous. Reliability

and durability are advancing by leaps and bounds. Until comparatively recently an engine which ran for 100 hr. without overhaul was considered to have done well, whereas, at the present day, the average time between overhauls is in the neighbourhood of 250 hr. The credit for this is not entirely due to improvement in engine design and construction, increased efficiency in maintenance of the engines being an important contributing factor. Research is being pressed forward on new types of engines, such as sleeve valve engines, and engines to run on heavy oil, while rumours are current that on the continent steam engines and turbines are being successfully developed for aeronautical use. The perfection of the heavy oil engine will effect a marked economy in running costs. These engines are essentially slow running engines, in consequence of which there should be a considerable reduction of wear and tear with its attendant saving in maintenance charges, while the cost of the fuel will show a further saving.

The last item in the classified list is "Improvement of comfort in aircraft." The fitting and decoration of modern commercial aircraft has already reached a high state of comfort. Heating, washing, and lavatory accommodation are universally provided, together with comfortable seating and excellent window arrangements, which afford a perfect view.

Progress is being made in the provision of adequate ventilation, but this, generally speaking, is by no means ideal. The main difficulty to be contended with is the prevention of draught while allowing for the entrance of fresh air.

The greatest hindrance to the comfort of air travel is noise. Exhaustive experiments are being conducted with a view to reducing this obnoxious feature, but considerable difficulty is being experienced. The noise emanates from three main sources, namely, the rapidly moving working parts of the engine, of which the valves and gears contribute the major portion, noise due to air vibrations set up

by the airscrew, and noise caused by vibration of parts of the aeroplane itself, in particular in the cabin walls. A considerable proportion of the noise could undoubtedly be reduced, but only at the expense of adding weight. Experience has shown that, generally speaking, metal aircraft are quieter than those made of wood and fabric. Further experiments in this imperfectly understood subject may show a way in which greater comfort in this respect may be achieved.

AIRSHIP DEVELOPMENTS

A vast amount of research work has been carried out in connection with airship design and construction, as the outcome of which, two airships are in the course of being built, one by the British Government, and the other by contract for the Government. Each of these will have a cubic capacity of five million cubic feet, which is considerably larger than anything which has previously been attempted. These airships will have a length of approximately 720 ft., and a height of 140 ft. Some idea of what this size means can be gauged from the fact that Nelson's column in Trafalgar Square could stand erect in the hangar in which one of these airships is being built.

It is estimated that they will have a cruising range of 4,000 miles, and a maximum speed of approximately 70 miles per hr.

The engines with which they will be equipped will develop about 3,250 h.p.

These airships will be fitted out with lounges, dining and smoking rooms, and sleeping accommodation sufficient to accommodate approximately 100 passengers, as well as the crew, and in addition, will carry a considerable weight of goods.

Many new principles of construction will be embodied in these ships, the girder and structure work of which will be mainly built of duralumin.

Hydrogen will be used to inflate them, but in order to

reduce risk of fire to a minimum, heavy-oil burning engines will be used in place of petrol engines. In the United States of America, helium, a non-inflammable gas, is used for

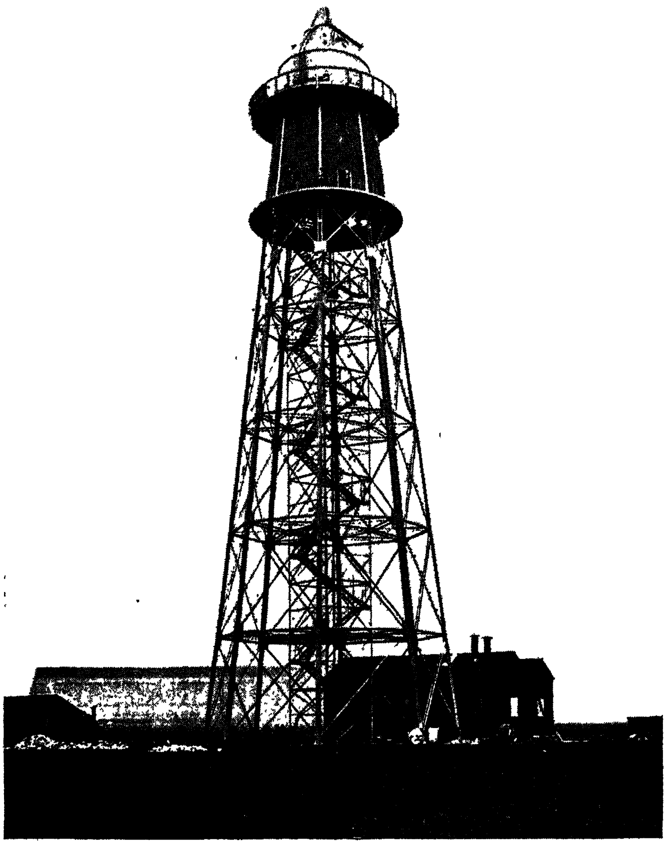


FIG. 17. AIRSHIP MOORING MAST
The new mooring mast erected recently at the Royal Airship Works, Cardington, near Bedford.

providing the lift, but as the supply of this gas is very limited, as its known existence in quantity is confined to America, and as it is extremely costly, it will not be

possible to use it for the ships which are now under construction in this country.

When completed, probably in 1928, these airships will carry out experimental flights from England to Karachi, in India, with one stop for refuelling purposes in Egypt.

One of the main factors which has rendered the use of airships a commercial possibility is the invention of the mooring mast, which does away with the necessity for hangars except at stations at which overhauls will be carried out, and obviates the necessity for large handling parties. The mooring mast, which varies in height, but will generally be in the neighbourhood of 200 ft., consists of a tower of girder construction. The top of the tower is fitted with a revolving head to which the nose of the airship can be coupled in such a manner as to provide a covered passage way from the head of the mast to the interior of the ship. The mast is provided with lifts for passengers and goods, with fuel, water, and gas pipes, which, when coupled to similar pipes in the ship, will render refuelling and gassing a simple and quick process.

The bringing of a ship to the mast for mooring purposes is accomplished by means of cables, one of which is paid out from the ship so as to reach the ground, the other being paid out from the head of the mast. These two cables are then coupled up, when by the aid of winches the ship is wound in to a position in which it can be connected to the mast head.

Airship hangars, which correspond to a ship's dry dock, will only be used for the purpose of carrying out overhauls. For all ordinary purposes, when in harbour, the airship will ride at the mooring mast, and it is the direct result of this ability to dispense with costly ground organization which has rendered the operation of airships a commercial possibility.

CHAPTER XVIII

THE APPLICATION OF AVIATION TO USES OTHER THAN TRANSPORT

THE field for the useful development of commercial aviation is constantly expanding.

During the war, one of the many activities of the Royal Air Force, on which it was more or less permanently employed, was air photography, as a result of which a constant record of work carried out on trench lines, battery positions, salient points, depots, etc., was obtained.

Besides this, in some theatres of war, of which only inaccurate maps existed, these were corrected and brought up to date, by making complete photographic mosaics of large areas.

Since the war, the methods used in the application of air photography to the purpose of map making have been steadily improved, until a very high state of perfection has been attained in the production of large scale accurate maps.

In unmapped countries, where quantity of output combined with approximate accuracy is of greater importance than absolute precision, new systems have been devised which make use of oblique instead of vertical photography.

Both systems are being largely employed in Canada and the United States of America, while the latter is being extensively used on the continent, and in parts of the Far East, such as Burma, Sarawak, and the Malay States.

Air photography, when applied to air survey in forest areas, serves two valuable purposes. It provides the necessary data from which a map can be made, and at the same time, supplies a record of classification of timber and the state of its growth.

Air photography is now being largely used for such purposes as making surveys in connection with railway construction, road building, power schemes, town planning,

factory reconstruction, estate development, and many other purposes, too numerous to mention.

For accurate map making the air surveyor works in the closest co-operation with the ground surveyor who must fix control points on the ground in order that photographs may be rectified and scaled, and who, before the finished map is completed, must go over the ground to fill in such details as names, classification of roads, etc., to which the photographs give no clue.

The great advantage of air survey over the old established method of ground survey is its rapidity, and, under favourable circumstances, its economy. Cost naturally varies according to the conditions. The larger the scale required, the more costly will the photography become; on the other hand, in such classes of country as thick forests, swamps, etc., where ground travel is slow and laborious, air survey shows a great advantage over ground survey, both in accuracy, time required, and cost.

Air survey has already arrived at that stage of development which calls for the services of very highly trained, skilful, and scientific personnel.

In Canada and the United States of America most valuable work is being done by utilizing aircraft to assist in the protection of the forests from the devastating effects of fires, which are a constant occurrence, and which annually account for the loss of timber of enormous value. This is done by carrying out regular and systematic patrols. The machines so engaged carry wireless by means of which they keep in close touch with forest fire fighting controls. Every outbreak of fire which is seen is immediately reported, giving its exact location and extent to the control, who then dispatches the nearest fire fighting squad to the scene, or, if the fire is at an unget-at-able place, the aircraft is ordered to land at a given spot, pick up the fire fighting squad with their fire fighting equipment, and fly them to a point in the neighbourhood of the fire at which it is possible to land.

As these forest areas are broken up by numerous lakes, flying boats, or float seaplanes are almost invariably used. Such valuable results have been obtained from the use of aircraft for the purpose of forest protection, and the estimated value of the timber saved is so enormous, while an actual economy has been effected in the forest fire fighting service, that it is only natural that a constant and insistent demand is being made for the employment of more and more aircraft.

In the United States of America aircraft are being largely employed to destroy the boll weevil, the ravages of which, in the cotton fields, causes an annual loss of several million pounds sterling. A company has now been formed especially to deal with this pest. Special machines have been designed to carry and distribute the powder with which the cotton crops are dusted, the rate quoted for doing this work being seven dollars per acre for five separate applications. As the very extensive areas under cotton cultivation have to be dusted frequently over a short period of the growing season, it follows that it can only be done imperfectly by the agricultural labourer, and then only if the supply of labour is adequate, which is never the case. Consequently, this new development in the use of aircraft is likely to grow to very large dimensions.

Aircraft are in constant use in Canada and the United States of America for the prevention of smuggling, and have been largely instrumental in reducing to reasonable proportions the import of illicit drugs. The method adopted by the smugglers is to drop packages of drugs, which are attached to floats, from vessels while they are still some distance out from port. These are picked up by confederates in, what purport to be, fishing boats. This is countered by aircraft meeting the ships when well out at sea and reporting to the shore custom authorities any craft of which they are suspicious, which are then met and inspected before they have an opportunity of making shore.

Another and somewhat analogous use of aircraft is

fishery protection which has been used extensively by the Canadian Government.

Experiments have been carried out in this country with a view to tracing the movement of fish shoals, but little success has so far been achieved owing to the lack of clearness in the water surrounding our shores, which renders it difficult to locate the fish.

Aircraft have been used to investigate the movement of spores and germs which attack certain crops, as the result of which a considerable amount of valuable information has been obtained.

In South America, mosquito destruction has also been undertaken by aircraft with a considerable measure of success.

These few examples of the manifold services to which aircraft are being applied make it clear that commercial aviation has a very real value quite apart from its use as a means of rapid transport, the full extent of which it is impossible to foresee at the present day.

CHAPTER XIX

THE FUTURE

IN spite of the developments which have taken place in the past few years, air transport must still be regarded as in its infancy, both from an operational and technical point of view.

The airship will undoubtedly play a great part in the expansion of air communications in the future.

The airship and the aeroplane are the complement of each other. The former will carry out the long non-stop flights between important world junctions, while the aeroplane will operate the feeder services radiating to and from these junctions, and carry out the independent services which do not connect with the airship trunk routes.

Every indication points to the conclusion that air transport, which has been floundering in a morass of uncertainty, has established itself in firm soil, and will from now onwards make strong and steady growth. Difficult times are still ahead, but that air transport has come not merely to exist, but to play a great part in the future progress of civilization, there can be little doubt. Already it has achieved much in the breaking down of barriers, the making of friendships, and the creation of goodwill and understanding. As an aid to commerce, even to-day, it is making itself felt, while the possibilities of the future are limitless.

In course of time the main trunk routes will be in operation day and night along the highways of the world, while shorter routes will radiate from them in all directions.

That regularity, reliability, and safety, will be attained to an extent equal to that of any other means of transport there can be no doubt, since, even to-day, a very high standard has been reached, and this will be far exceeded when the technical developments, which are almost perfected, are taken into practical use.

It is possible now to predict with a certain amount of assurance the time which must elapse before air transport reaches the stage when it can pay its way without the aid of artificial assistance, using in the meantime such aircraft and material as are at present in sight. What, then, may the future bring forth when technical developments which are only vaguely imagined to-day, become, perhaps, a reality ?

And what of these developments ? To-day, we have the auto-gyro and the tailless monoplane, both accomplished facts, though not yet practical propositions from an air transport point of view; nevertheless, further development may prove them to be of immense value. Tales are told of a flying wing which is being developed on the continent. If rumour speaks true this consists of a huge thick wing monoplane, the depth of which is seven feet, and inside, it is fitted with cabin accommodation, engine room, quarters for crew, fuel storage, etc. This machine will have no body, merely one plane, the leading edge of which is more or less straight, while the trailing edge is arc shaped. It is suggested that unusual control surfaces will be fitted, while an entirely novel form of engine will be used. It is also told that this flying wing will travel at 170 miles per hr., for six hours, while carrying a paying load of fifteen tons.

This machine may be an hallucination on the part of its designer, or maybe it's a myth, but the fact that such imaginings exist among serious and extremely clever technical people, and that machines such as the auto-gyro and the tailless monoplane, so far removed from normal recognized practice, have actually been built and flown, proves conclusively that there is no certainty that the line of development, which has been almost universally followed, is the one which will prove ultimately to be the most effective.

Air transport is no longer the dangerous and haphazard thing which many still regard it. It has come to take its place in the scheme of evolution which is unfolding so rapidly, aided by modern science. It has come to bridge

time for matter in the same way that electricity made it possible to bridge time for mind.

The day is not far distant when commercial aviation will come into its own, and let him who places a value on progress, fail not to take stock of it.

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